REPORT RESUMES

ED 014 429 24 SE 003 459

THE COMPARATIVE EFFECTIVENESS OF TWO METHODS OF TEACHING GRADE SCHOOL SCIENCE.

BY- DRENCHKO, ELIZABETH K.

RUTGERS, THE STATE UNIV., NEW BRUNSWICK, N.J.

REPORT NUMBER CRP-S-351 PUB DATE 66

REPORT NUMBER BP-5-8054

EDRS PRICE MF-$0.50 HC-$4.08 100P.

DESCRIPTORS- *ACADEMIC ACHIEVEMENT, *EFFECTIVE TEACHING, *ELEMENTARY SCHOOL SCIENCE, *INSTRUCTION, *TEACHING METHODS, BIOLOGY, BIBLIOGRAPHIES, CONCEPT FORMATION, COMPARATIVE ANALYSIS, EDUCATIONAL OBJECTIVES, EARTH SCIENCE, GENERAL SCIENCE, GRADE 4, PROBLEM SOLVING, PHYSICAL SCIENCES, SEQUENTIAL TEST OF EDUCATIONAL PROGRESS (SCIENCE TEST FORM 4A), SEQUENTIAL TEST OF EDUCATIONAL PROGRESS (SCIENCE TEST FORM 4B),

THE EFFECTIVENESS OF TWO METHODS, RECITATION-DEMONSTRATION AND PROJECT-RESEARCH, WERE COMPARED FOR TEACHING ELEMENTARY SCHOOL SCIENCE. COMPARISONS WERE MADE REGARDING (1) THE KNOWLEDGE OF THE SUBJECT MATTER ACQUIRED BY THE STUDENT, (2) THE ABILITY OF THE STUDENT TO UNDERSTAND AND APPLY CONCEPTS AND GENERALIZATIONS OF THE SUBJECT, AND (3) THE WORK STUDY SKILLS DEVELOPED BY THE STUDENT. THE SAMPLE WAS COMPRISED OF FOURTH GRADE STUDENTS IN CLASSES SELECTED RANDOMLY FROM FOUR SCHOOLS IN THE HILLSBOROUGH TOWNSHIP PUBLIC SCHOOLS. ONE CLASS IN EACH SCHOOL WAS TAUGHT BY RECITATION-DEMONSTRATION METHODS, ONE BY PROJECT-RESEARCH METHODS WITHOUT INDIVIDUAL PROJECTS, AND ONE BY PROJECT-RESEARCH METHODS WITH INDIVIDUAL PROJECTS. THE RECITATION-DEMONSTRATION GROUP WAS TAUGHT BY REGULAR ASSIGNMENTS, QUESTION AND ANSWER RECITATIONS, AND DEMONSTRATIONS PERFORMED PREDOMINANTLY BY STUDENTS. THE PROJECT-RESEARCH GROUP COVERED THE SAME TOPICS, BUT THEY WERE GIVEN A GENERAL PROBLEM TO SOLVE. THE LATTER GROUP WAS ALSO GIVEN INQUIRY TRAINING SUCH AS THE "YES-NO" RESPONSE TECHNIQUE. THE GROUPS WERE PRETESTED AND POST-TESTED USING INVESTIGATOR CONSTRUCTED UNIT ACHIEVEMENT TESTS AND STEP SCIENCE TESTS. IT WAS CONCLUDED THAT (1) IN TERMS OF GROWTH IN SUBJECT MATTER KNOWLEDGE THE PROJECT-RESEARCH METHOD WITHOUT INDIVIDUAL PROJECTS APPEARS TO BE SUPERIOR TO THE PROJECT-RESEARCH METHOD WITH PROJECTS AND THE RECITATION-DEMONSTRATION METHOD, (2) MOST STUDENTS OF THIS AGE GROUP ARE NOT PREPARED TO HANDLE INDIVIDUAL PROJECTS OF THE TYPE USED IN THIS STUDY, AND (3) THERE WERE NO SIGNIFICANT DIFFERENCES BETWEEN METHODS AND GROWTH IN (A) PROBLEM SOLVING ABILITY, AND (B) WORK STUDY SKILLS. MORE STUDENTS IN THE PROJECT-RESEARCH GROUPS HAD GREATER INTEREST IN SCIENCE AT THE END OF THE STUDY. RECOMMENDATIONS FOR FURTHER RESEARCH AND AN EXTENSIVE BIBLIOGRAPHY ARE PROVIDED. (DS)

SE 003 459

ED014429

BR-5-8054
PA-24

U.S. DEPARTMENT OF HEALTH, EDUCATION & WELFARE
OFFICE OF EDUCATION

THIS DOCUMENT HAS BEEN REPRODUCED EXACTLY AS RECEIVED FROM THE PERSON OR ORGANIZATION ORIGINATING IT. POINTS OF VIEW OR OPINIONS STATED DO NOT NECESSARILY REPRESENT OFFICIAL OFFICE OF EDUCATION POSITION OR POLICY.

THE COMPARATIVE EFFECTIVENESS OF TWO METHODS OF TEACHING GRADE SCHOOL SCIENCE

Cooperative Research Project No. S-351

ELIZABETH K. DRENCHKO
RUTGERS · THE STATE UNIVERSITY
NEW BRUNSWICK, NEW JERSEY

1966

The research reported herein was supported by the Cooperative Research Program of the Office of Education, U. S. Department of Health, Education, and Welfare.

TABLE OF CONTENTS

Page

TABLE OF CONTENTS iv

LIST OF TABLES. v

LIST OF FIGURES vi

THE PROBLEM 1

HYPOTHESES. 11

RELATED RESEARCH. 12

PROCEDURE 28

ANALYSIS OF DATA. 37

CONCLUSIONS 45

APPENDIX A - LESSON PLANS. 51

APPENDIX B - TOPIC TESTS 77

BIBLIOGRAPHY. 90

LIST OF TABLES

Table Page

1. Analysis of Variance fof Unit Tests. . 38
2. Analysis of Variance for Age 39
3. Analysis of Variance for Achievement Scores 39
4. Analysis of Variance for I.Q. Scores . 39
5. Analysis of Covariance for Topic Test Scores Using I.Q. Scores as a Control. 41
6. Analysis of Covariance for Topic Test Scores Using Achievement Scores as a Control. 41
7. Analysis of Covariance for STEP Tests Using I.Q. Scores as a Control . . . 43
8. Analysis of Covariance for STEP Tests Using Achievement Scores as a Control. 43
9. Analysis of Covariance for Work Study Skills Using I.Q. Scores as a Control. 44
10. Analysis of Covariance for Work Study Skills Using Achievement Scores as a Control. 44

LIST OF FIGURES

Figure Page

1. Data Sheet 36

2. Acquisition of Subject Matter, Achievement as Covariate 46

3. Acquisition of Subject Matter, I.Q. as Covariate. 46

THE PROBLEM

Science, in one form or another, has been an integral part of the elementary program since the middle of the nineteenth century. Most of this science was directed toward specific topics directly related to the home life of the students.[1]

During and following World War II, interest in science increased tremendously. Advances made by military scientists effected the quality and quantity of science in high schools and colleges. Science instruction lagged in elementary schools because population increases made other problems, such as pupil-teacher ratio and financial burden more urgent. Time and effort were used to maintain current programs rather than initiate changes.

Although a great deal of thought and talk took place concerning the place of science in the curriculum, little action occurred until the advent of Sputnik.[2] Science was placed in the elementary school whether the school was

---

1. Cyrus Barnes, "Problems of Research and Implications in Teaching Science in the Elementary School," School Science and Mathematics 61 (November, 1961) 595-600.
2. J. Darrell Barnard, "Developments in Science Education," Educational Leadership 19 (January, 1962) 215-219.

prepared or not. Science educators wanted science in the curriculum. With the people now behind them, a decision had to be made concerning what to teach and when to teach it. This is still an open question, but one point seems to be universally accepted by all involved; science programs must be sequential, beginning with Kindergarten and continuing through high school.[3] This idea is by no means new, but even so some schools are only now putting it into practice.

Today is an age of science. Whether children go on to become scientists or not, tney need to learn scientific principles, applications, and methods in order to live intelligently and effectively. Science is no longer considered merely as a body of facts, but also as a method of thinking, a way of solving problems.

The literature in science has become so great that scientists have trouble trying to keep up with it.[4] This fact helped bring scientists and educators together to work out a system of teaching science so students would be prepared for scientific work after school. New methods to approach science teaching in the secondary schools arose from these meetings.[5] This also brought about the learning of concepts earlier than previously. As a result, it is thought necessary to revise the elementary science program to keep pace. Science information "... has increased to the place that they (the children) start to study science today knowing more science than children did twenty-five years ago after they had studied science."[6]

---

[3] Gary R. Smith and Edward Victor, "Use of Standardized Science Achievement Tests for Grade Placement," _The Science Teacher_ 28 (February, 1961) 11.

[4] Barry Commoner, "Is Science Getting Out of Hand?" _The Science Teacher_ 30 (October, 1963) 11-16.

The need for revision and sequential order caused many schools to set up a course of study indicating what should be taught and when. Most courses of study list various topics with the facts to be learned in specific grades.[7,8] Having a course of study, however, does not necessarily mean that good science will be taught, for good science teaching, to a great extent, depends on the teacher.

Teachers are not expected to have all the answers to science problems, but to understand the way in which scientists work. There is no deep mystery about this,

---

5. Paul DeHart Hurd, "The New Curriculum Movement in Science," The Science Teacher 29 (February, 1962) 6-9.
6. Donald G. Decker, "Trends in Sequence and Organization," Instructor 73 (January, 1964) 43+.
7. Jacqueline V. Mallinson, "Current Status of Science Education in the Elementary Schools," School Science and Mathematics 61 (April, 1961) 252-270.
8. Gerald S. Craig, "Elementary School Science in the Past Century," The Science Teacher 24 (February, 1957) 11-14+.

for all scientists work in the same general way. They formulate a problem, study the facts that are known, make a guess as to the solution of the problem, then test their guess. If the guess is not right, scientists start over again. Essentially this is the same process by which anyone solves a problem.[9] Scientists, however, add an extra step,[10] that is, to see if their solution also applies in similar situations.

Different methods of teaching are used by teachers in various subjects, but methods such as laboratory work apply most directly to scientific fields. Science today is taught in a variety of ways in the elementary school. Among the most common are the following:

Reading: In some classrooms the science period is mainly a reading period when the children cover assigned pages and answer questions about what they have read. This is the type of instruction one expects to find when teachers are poorly prepared or have little time set aside in their already too busy day. Providing that the reading has been well motivated, it helps the child acquire needed information, but teaches nothing of the problem solving procedures which are so important.

---

[9] Lee J. Cronbach, Educational Psychology. New York: Harcourt, Brace & World, Inc., 1963. pp 371-378.

[10] W. C. VanDeventer, "A Common Denominator for Scientific Problem Solving," The Science Teacher 27 (February, 1960) 41-42.

Lecture-demonstration: In this type of teaching, the teacher does most of the active participation except the reading of assignments and note taking. The class sits listening to whatever the teacher has to say and should be taking notes on what is said. When demonstrations are felt to be necessary, the teacher performs them and there is some discussion following the demonstrations.

Recitation-demonstration: Recitation is usually thought of as a sequence of oral questions and answers. This method also includes demonstrations and considerable discussion as well. This in itself could be simply an extension of the reading or lecture-demonstration methods, but when demonstrations by the students, in addition to any performed by the teacher, are added, it is no longer the same. Demonstration can be used to introduce a principle or after discussion of a principle to see if the students can determine where and how the principle applies. The student is involved although the principle is sure to concern the recent class discussions or reading assignments. The advantage is there for the demonstration takes less time than discussion to obtain the same results. According to Weaver, "Confucius say: One picture = words x 10^3. Science teacher say: One demonstration = words x 10^5."[11]

Activity: The activity method of teaching science differs from the demonstration in that the entire class is physically as well as mentally involved.[12] Students perform the demonstrations; or perhaps the student does an experiment and reports the results to the class as a whole.

Class Project and Experiment: In this method of science teaching, the entire class works towards the solution of a project or experiment. Whether it is a class project where each student has a different part to play or an experiment where each student is doing the same thing, each student is taking part in the solving of a problem.

Independent Study: Keeping in mind that any experiment can serve the purpose, if the experimenter does not already know the conclusion,[13] there is no reason why independent study cannot be successfully done in the

---

11. Elbert C. Weaver, "Demonstration IS Teaching," The Science Teacher 31 (February, 1964) 34-35.
12. Jerry L. Norton, "The Need for an Activity Centered Science Program," Science Education 47 (April, 1963) 285-291.
13. Franklyn M. Branley, "Experiments and Demonstrations," Grade Teacher 78 (October, 1960) 53, 125+.

elementary school. However, before setting out on such a plan, the teacher must do a lot of preparation. The students who are expected to do independent study must be prepared in such a way that they can choose problems and work toward a satisfactory conclusion without turning constantly to the teacher for help. Of course, the teacher is there, if help is needed.

Tactics and methods of the scientist which could be used in any independent study include:[14]

> The planned investigation, reflective thinking, inspiration, the 'educated guess', trial-and-error, accidental discovery, reference to authority, developing new concepts and problems, using a logbook (and) making a final written report.

Problem solving allows science concepts to be developed within the student's understanding. When these concepts are told to students, solutions are being given for which no problem exists at the time.[15] Under these circumstances, students often have difficulty applying the concepts when needed. Students learn concepts more thoroughly and also put these concepts into use more

---

14. Donald Wynant Huffmire, "Criteria for Independent Study Projects," The Science Teacher 28 (May, 1961) 32-33+.
15. Melvin Hetland, "Developing Science Concepts Inductively," The Science Teacher 24 (May, 1957) 172-173+.

readily when they are taught in a problem solving manner,[16] for:[17]

> Pupils are challenged when asked to discover a solution. This motivates them to pay closer attention and to think about the material outside of class. The solution, when achieved, contributes to a sense of competence and to interest in further learning.

With all these methods for teaching science available to the teacher, the choice of method becomes more difficult and important.

It is the purpose of this study to compare two of these methods, recitation-demonstration and project-research, in the fourth grades in Hillsborough Township Public Schools. Students' acquisition of subject matter and solutions to problems as based on test results will be used to make the comparison.

Definitions: 1. A problem is considered to be a question of such a nature that solution will involve more than looking the answer up readily in a book.

2. Problem solving in this study refers to the student's ability to move from one part of a problem to

---

[16] Murray D. Dawson, "Lectures Versus Problem Solving in Teaching Elementary Soil Science," Science Education 40 (December, 1956) 395-404.
[17] Lee J. Cronbach, op. cit., pp 379-380.

the next, not necessarily from the beginning through to a final solution. The student must be able to identify a method of solution which will enable him to recognize the steps of the solution rather than the actual solution.

3. Recitation-demonstration is that method in which each lesson is characterized by a specific assignment given to the students. Work is not limited to these assignments, however. Teacher-student or student-student discussion and question-answer periods follow, although under control of the teacher at all times. Demonstrations involving various principles under study are performed by teacher or student specifically chosen to do so.

4. Project-research is that method in which a general problem covering a topic is presented to the class. The general problem is of such a nature, that the students must draw conclusions from the information obtained through reading, experimenting, and discussing. The solution of this problem serves as their "project." Through group leadership, the teacher draws suggestions from students on how to solve the problem. Students are encouraged to read as much as possible without being given specific assignments and to perform experiments about which they have read. The teacher keeps students headed in the general direction of a solution without actually giving

the next, not necessarily from the beginning through to a final solution. The student must be able to identify a method of solution which will enable him to recognize the steps of the solution rather than the actual solution.

3. Recitation-demonstration is that method in which each lesson is characterized by a specific assignment given to the students. Work is not limited to these assignments, however. Teacher-student or student-student discussion and question-answer periods follow, although under control of the teacher at all times. Demonstrations involving various principles under study are performed by teacher or student specifically chosen to do so.

4. Project-research is that method in which a general problem covering a topic is presented to the class. The general problem is of such a nature, that the students must draw conclusions from the information obtained through reading, experimenting, and discussing. The solution of this problem serves as their "project." Through group leadership, the teacher draws suggestions from students on how to solve the problem. Students are encouraged to read as much as possible without being given specific assignments and to perform experiments about which they have read. The teacher keeps students headed in the general direction of a solution without actually giving

direct answers to questions. Classroom discussion, moderated by the teacher, brings together information obtained through individual "research."

Assumptions: Projects of the sort intended here can be adequately handled by individual students in a self-contained classroom.

Equipment necessary for the projects can be adequately handled by individual students in a self-contained classroom.

Project-research and recitation-demonstration methods can be handled equally efficiently by the average elementary classroom teacher.

The fourth grade teachers of Hillsborough Township have had no special training in teaching science and can, therefore, be considered to be average elementary classroom teachers for the purpose of this study.

Students in the fourth grades of Hillsborough Township Schools are typical of those found in similar communities.

Limitations: The individual projects studied will of necessity be simple ones, because of the age and development of the students involved in the study. Since these projects were done within the classroom, amount and size of equipment used was restricted.

HYPOTHESES

The objective of this study is to compare the recitation-demonstration and project-research methods of teaching science. With this in mind, the following null hypotheses are to be tested:

1. There is no difference between the recitation-demonstration method and the project-research method of teaching science in the elementary school with respect to:

    a. the knowledge of the subject matter acquired by the student, and

    b. the ability of the student to solve problems, that is, to understand and apply concepts and generalizations of the subject

as indicated by paper and pencil test scores.

2. There is no difference regardless of the sex of the students.

3. There is no difference regardless of the intelligence of the students.

4. There is no difference in the work study skills developed by the students.

RELATED LITERATURE

Science has forced itself into the foreground, and, as shown, several methods are available by which to teach it. Is one method better than another? Perhaps we should find out; for, if one method is superior to the others, it might be a good idea to use that one and forget the others.

In an effort to find out whether various methods have been tested, it became apparent that very little has been done at the elementary level of teaching. Johnson[18] summarized seventy-two research studies done in 1952. Only ten of these dealt with the elementary school in any way - including training of elementary teachers, and none of them was involved with a study of teaching methods. This is, of course, only one year; but when the number of people who attend elementary school and the number who attend, or finish, high school and college are considered, it would seem wise to spend more time improving the basic learning years.

College level studies

Working with college students, Alterman[19] compared the effectiveness of a demonstration and simple illustration method of teaching physics. Using pretests and posttests with several standard physics tests, he found the difference between the two methods was not statistically significant according to a t-test.

---

[18] Philip G. Johnson, "Science Education Research Studies-1952," Science Education 38 (February, 1954) 8-38.

[19] George Alterman, "A Comparison of the Effectiveness of Two Teaching Techniques on the Ability of College Students to Apply Principles of Physics to New Technical Problems," Unpublished Ph.D. dissertation, New York University, 1957.

Starting with the null hypothesis that there was no difference, Kruglak[20] compared the method of lecture and individual laboratory work with a demonstration method in college physics. He rejected his null hypothesis at the 1% level after using analysis of variance and covariance in a 2 x 4 randomized block design. He found the conventional method to be superior.

In a study of the biological sciences, Mason[21] found a descriptive method of teaching to be better than a scientific thinking method on a short term basis. However, on a long term retention, both methods were found to be about equal.

Using the Hanfmann-Kasanin or Vigotsky Block Test,[22] Carpenter had one group memorizing facts about the blocks while a second group was manipulating the blocks. He found through the use of Chi Square that the group that had manipulated the blocks did significantly better, at the 1% level, in forming concepts.

---

20. Haym Kruglak, "A Comparison of the Conventional and Demonstration Methods in the Elementary College Physics Laboratory," Journal of Experimental Education 20 (March, 1952) 293-300.
21. John M. Mason, "An Experimental Study in the Teaching of Scientific Thinking in Biological Science at the College Level," Science Education 36 (December, 1952) 270-284.
22. Finley Carpenter, "The Effect of Different Learning Methods on Concept Formation," Science Education 40 (October, 1956) 282-285.

Barnard[23] compared a lecture demonstration and a problem solving method of teaching science. He determined that for abilities to solve problems and in scientific attitudes, those under the problem solving method did significantly better; but that understanding of generalizations and specific information showed no significant difference between the two methods.

It has been found[24] that students working with a problem-solving method did significantly better than those using a lecture method.

Perhaps these few studies are not enough to prove anything, but on this basis, it would appear that the method in which the student is actively participating is as good as or better than the other methods considered.

High school level studies

Abramson[25] taught classes in high school mechanics by two different methods. One group used the lecture-demonstration method. The other group was taught by discussing ideographs, that is, pictures illustrating a

---

23. J. Darrell Barnard, "The Lecture-Demonstration Versus the Problem-Solving Method of Teaching a College Science Course," Science Education 26 (October, 1942) 121-132.
24. Murray D. Dawson, "Lectures Versus Problem Solving in Teaching Elementary Soil Science," Science Education 40 (December, 1956) 395-404.
25. Bernard Abramson, "A Comparison of Two Methods of Teaching Mechanics in High School," Science Education 36 (March, 1952) 96-106.

concept of mechanics. In general, there was no difference between the two methods, however, the ideograph method seemed to work better for the poor reader or limited ability student.

The lecture discussion method of teaching biology in which one group read assignments in class, another group read them outside of class, and a third group had no reading assignments either in or out of class was studied by Newman.[26] Using pre and post tests as comparisons, he found no significant difference between the three groups.

The lecture demonstration method has been compared with an individual laboratory method and a group laboratory method[27] in the teaching of biology. It was found that the lecture demonstration method came out somewhat better, but not significantly so.

Audio visual aids have played their part in the study of high school physics teaching. The Harvey White

---

26. Earl Nelson Newman, "A Comparison of the Effectiveness of Three Teaching Methods in High School Biology," Unpublished Ed.D. dissertation, University of Oklahoma, 1957.
27. Palmer O. Johnson, "A Comparison of the Lecture Demonstration, Group Laboratory Experimentation, and Individual Laboratory Experimentation Methods of Teaching High School Biology," Journal of Educational Research 18 (September, 1928) 103-111.

Physics Film A Day[28] was used with one group, while the second group was taught in the usual lecture-recitation-laboratory. Television was used with three groups;[29] one used television only, one used television supplemented by a teacher, and the third group used the usual techniques as above. Both studies showed no significant differences between the various methods used.

A comparison was made by Benz[30] between showing slides and actually taking field trips in an Earth Science class. It was shown that superior students appeared to gain more from field trips, but there was no significant difference.

Colyer and Anderson[31] were concerned with formula writing in the teaching of high school chemistry. Using two groups, they taught formula writing in the traditional method of memorization, and the sequence method of understanding why certain things were written certain ways. They found the experimental or sequence method was significantly better at the 5% level.

---

[28] Leonard James Garside, "A Comparison of the Effectiveness of Two Methods of Instruction in High School Physics as Measured by Levels of Achievement of Students of High and Low Intelligence," Unpublished Ph.D. dissertation, University of Wisconsin, 1959.

[29] George Wendell Hubbard, "The Effect of Three Teaching Methods on Achievement in a Senior High School Physics Course," Unpublished Ed.D. dissertation, University of Oklahoma, 1958.

[30] Grace Benz, "An Experimental Evaluation of Field Trips for Achieveing Informational Gains in a Unit on Earth Science in Four Ninth Grade Classes," Science Education 46 (February, 1962)43-47.

[31] Luther Melvin Colyer and Kenneth E. Anderson,"A Comparison of Two Methods of Teaching Formula Writing in High School Chemistry," School Science and Mathematics 52 (January, 1952) 50-59.

Falk[32] also found a meaningful presentation of chemical equations to be superior to the mechanical method of learning equations.

Laboratory work plays a large part in high school science, and many studies have included the laboratory within them. Carpenter[33] was concerned primarily with the laboratory practices. One group was taught through demonstrations only, another group did individual laboratory work, and a third group worked in pairs on the laboratory work. He found that the first two groups did equally well, but the third group did not do as well as either of the others.

The inductive-deductive approach to the laboratory was compared with the deductive-descriptive approach.[34] The experimenter found the inductive-deductive approach was better for teaching laboratory in high school chemistry.

The lecture-demonstration and individual laboratory

---

32. Doris F. Falk, "The Learning of Chemical Equations: Meaningful Versus Mechanical Methods," Science Education 46 (February, 1962) 37-42.

33. W. W. Carpenter, "A Study of the Comparison of Different Methods of Laboratory Practice on the Basis of Results Obtained on Tests of Certain Classes in High School Chemistry," Journal of Chemical Education 3 (July, 1926) 798-805.

34. Clarence H. Boeck, "The Inductive-Deductive Compared to the Deductive-Descriptive Approach to Laboratory Instruction in High School Chemistry," Journal of Experimental Education 19 (March, 1951) 247-253.

methods of teaching high school chemistry appear to be the two most common methods used. Anibel,[35] Elder,[36] and Knox[37] all did studies comparing the two. These men all found the lecture demonstration method to be better, but not significantly so. In addition, Elder[38] pointed out that the students preferred to work themselves and wanted individual laboratory work, while Knox[39] indicated that the individual laboratory was actually somewhat better for the below average student.

These three studies, along with a considerable number of others were summarized by Cunningham.[40] He reviewed twenty-eight studies. On the basis of immediate results he found twenty favored the demonstration method, while only six favored the individual laboratory method and two did not favor either one. He continued to study delayed results and found twenty-four studies which considered this aspect. Of these, ten favored demonstration and eleven favored the individual laboratory and three did not indicate a favorite. This would seem to indicate that both methods are actually good.

---

[35] Fred G. Anibel, "Comparative Effectiveness of the Lecture Demonstration and Individual Laboratory Method," Journal of Educational Research 13 (May, 1926) 355-365.

[36] Albert L. Elder, "The Lecture-Demonstration Method vs Individual Laboratory Work in Chemistry," Science Education 23 (April, 1939) 209-215.

[37] W. W. Knox, "The Demonstration Method Versus the Laboratory Method of Teaching High-School Chemistry," Science Review 35 (May, 1927) 376-386.

[38] Albert L. Elder, op. cit.

[39] W. W. Knox, op. cit.

[40] Harry A Cunningham, "Lecture Demonstration Versus Individual Laboratory Method in Science Teaching - A Summary," Science Education 30 (January, 1946) 70-82.

Rainey found no significant difference between the conventional approach and the new CHEM Study Curriculum for chemistry.[41]

Three methods were considered by Nash and Phillips.[42] In one method the pupils worked at their own speed on whatever they wanted. In another method the demonstration-lecture-recitation as usual were used, and in the third method the instructor did everything. The students did no reciting or laboratory work. They found the last method, where the instructor did all the work to be somewhat superior to either of the other two methods.

In all of these studies concerning the high school, the authors used pretests and posttests as their measure of change. They also used the results of one or two standard tests as a means of equating the groups. Analysis

---

41. Robert G. Rainey, "A Comparison of the CHEM Study Curriculum and a Conventional Approach in Teaching High School Chemistry," School Science and Mathematics 64 (October, 1964) 539-544.

42. H. B. Nash and M. J. W. Phillips, "A Study of the Relative Value of Three Methods of Teaching High School Chemistry," Journal of Educational Research 15 (May, 1927) 371-379.

of variance and analysis of covariance were used to analyze their data. Some difference was found in all the studies between the methods used, but only a few found any significant difference.

Elementary school level studies

Several studies have been conducted to see whether the training received by the teachers has any effect on the learning of the students. Stefaniak[43] compared the achievement of fourth, fifth, and sixth graders divided into groups according to the teaching method received by their teachers. The teachers had been trained by the lecture-demonstration and individual laboratory methods. Overall data showed no significant differences. However, the fourth graders seemed to gain more under teachers trained in the lecture demonstration method while the fifth and sixth graders seemed to gain more under teachers trained by the individual laboratory method.

Mork[44] was interested in whether teachers could improve their effectiveness through an in-service training program. Some teachers, therefore, began in-service programs while other teachers did not. The students under these two groups were tested. The gain made by students whose teachers were in the in-service program was significantly different from the other group.

---

[43] 43. Edward W. Stefaniak, "A Study of the Effectiveness of Two Methods of Teaching Science in Grades Four, Five, and Six," Unpublished Ed.D. dissertation, Boston University School of Education, 1955.

[44] 44. Gordon Matther A. Mork, "Effects of an In-Service Teacher Training Program on Pupil Outcomes in Fifth and Sixth Grade Science," Unpublished Ph.D. dissertation, University of Minnesota, 1953.

One study was made simply to find out whether students suffered as a result of having an inferior or poorly planned science program.[45] It was found that schools with poor programs usually had poorly prepared teachers in the science field and the students who suffered most were the below average and just average students.

Another study was made by Gibb and Matala[46] to see whether it would be advantageous to use special science and mathematics teachers in the elementary school, rather than the regular classroom teacher. Although they had several classes taught by the regular classroom teacher and others taught by special teachers within the same schools and grade levels, their conslusions were not definite. Analysis of variance techniques were used to interpret the data obtained, but could only determine that there was evidence to indicate special teachers did a better job in science but not in mathematics. They could not, however, reject their null hypothesis that there was no difference between classes taught by one or several teachers.

---

[45] Donald Allen Boyer, "A Comparative Study of the Science Achievement of Pupils in Elementary Schools," Science Education 39 (February, 1955) 3-12.

[46] Glenadine E. Gibb and Dorothy C. Matala, "Study on the Use of Special Teachers of Science and Mathematics in Grades 5 and 6," School Science and Mathematics 62 (November, 1962) 565-585.

In a similar study by DiLorenzo[47] the hypothesis that special teacher groups would do better had to be rejected.

Ginther[48] also studied the use of science consultants. With one group the consultants saw only the teacher and the regular teacher did all work with the students. The other group had the consultant actually teach once a week and the regular teacher followed-up on the work. Through analysis of variance and covariance, they found a significant difference between the roles of the consultants. The group which dealt indirectly with the consultant was superior to the group which the consultants actually taught.

Gibb and Matala[49] pointed out that it was highly possible that it was the teaching method not the teacher that effects the understanding of the subject. To go along with this idea, Hosley[50] tested the difference between schools set up on a K-6 basis of self-contained classrooms and schools on a 6-8 grade semi-departmental basis. He could find no difference between the learnings of the two groups.

---

[47] Louis T. DiLorenzo,and Joseph W. Halliwell, "A Comparison of the Science Achievement of Sixth Grade Pupils Instructed by Regular Classroom and Special Science Teachers," Science Education 47 (1963) 202-205.

[48] J. R. Ginther, "Achievement in Sixth Grade Science Associated with Two Instructional Roles of Science Consultants," Journal of Educational Research 57 (September, 1963) 28-33.

[49] Glenadine E. Gibb and Dorothy C. Matala, op.cit.

Conversely, Boeck[51] came to the conclusion that it might be the teacher and not the method that made the difference, after finding no significant difference between a reading method and demonstration method of teaching science. According to Scott[52]

> ...major instructional failures seem to be associated more clearly with teachers' lack of knowledge in science than with any other factor.

In finding out the difference in teaching methods and their effect on the student, it was found that students in Junior High School grades seven and eight had an extremely high interest in science, but by the time they reached ninth grade, their interest was down at the bottom of the ladder. According to Norton[53] this is due mostly to the lecture-recitation method of teaching which is most often used at this level. He also points out that beginning teen-agers need to be active themselves, not just sitting around listening. He feels that interest would remain high if the students were permitted to perform within the class.

---

[50] Charles T. Hosley, "Learning Outcomes of Sixth Grade Pupils Under Alternate Grade Organization Patterns," Unpublished Ed.D. dissertation, Stanford University, 1954.

[51] Clarence H. Boeck,, "The Relative Efficiency of Reading and Demonstration Methods of Instruction in Developing Scientific Understandings," Science Education 40 (March, 1956) 92-97.

[52] Lloyd Scott, "An Experiment in Teaching Basic Science in the Elementary School," Science Education 46 (March, 1962) p.108.

Perhaps Carpenter felt the same way when he compared a reading recitation method with a problem solving method[54] involving experimentation and demonstrations. He worked with fourth grade students and both groups taught the same topics for the same length of time. He also reversed the groups on some of the topics. In both cases, the groups using the problem solving method tested significantly higher on mean scores using the t-test. Carpenter also broke his data down to test the high and low intelligent students. For those in the top quarter of the class, the group in the problem solving showed higher gains than the other group, but the difference was not enough to be statistically significant. When looking at the bottom quarter of the group, those in the problem solving method were extremely statistically significant.

---

[53] Jerry L. Norton, "The Need for an Activity Centered Science Program," Science Education 47 (April, 1963) 285-291.
[54] Regan Carpenter, "A Reading Method and an Activity Method in Elementary Science Instruction," Science Education 47 (April, 1963) 256-258.

Current events entered the picture when Kahn[55] tried to teach scientific attitudes to seventh and eighth grade boys. They analyzed science articles each class period. Measuring his group and another that did not use current events, before and after to see what gain was made, he found no difference in knowledge obtained, but a significant difference was observed in scientific attitudes acquired by the boys.

In 1929 Collings[56] set up an experiment with several country schools in which some of them introduced an activity program, that is, the children were actually involved in their studies rather than sitting passively listening. The experiment took place over a four-year period and ended with the author pointing out that the children in the project groups gained in interest, attitudes, and knowledge over the control groups. The author also points out, however, that his figures were not scientifically reliable.

Ten years later the New York City Schools were

---

55. Paul Kahn, "An Experimental Study to Determine the Effect of a Selected Procedure for Teaching the Scientific Attitudes to Seventh and Eighth Grade Boys Through the Use of Current Events in Science," Science Education 46 (March, 1962) 115-127.

56. Ellsworth Collings, An Experiment with a Project Curriculum. New York: The Macmillan Company, 1929.

evaluating their activity program.[57] Their studies showed that the activity program appeared to be better, but none of the results were statistically significant.

In 1937 Greene[58] was working with a slightly different form of activity than is usually thought of in connection with science. He worked with dramatics. Puppets, marionettes, and live productions were used to present scientific facts through dramatic productions while another group was simply taught the same material. Pretest and posttest were used to measure gains which were analyzed by use of the t-test. He found that there was no difference between the two methods as far as learning of factual knowledge was concerned. When time for learning these facts was considered, however, the dramatic presentation was only one-sixth as efficient.

A study guide method was compared with a developmental discussion method by Robertson.[59] He found the developmental discussion method was slightly better, but not

---

57. Arthur T. Jersild, et.al., "An Evaluation of Aspects of the Activity Program in the New York City Public Elementary Schools," Journal of Experimental Education 8 (December, 1939) 166-207.
58. Robert Alonzo Greene, "A Comparative Study of the Efficiency of Dramatic and Non-Dramatic Methods in Teaching Science to Fifth Grade Children," Unpublished Doctor's Thesis, Cornell University, 1937.
59. Martin L. Robertson, "An Investigation to Determine the Relative Effectiveness of Two Methods of Teaching Elementary Science in the Fifth Grade," Science Education 16 (February, 1932) 182-187.

significantly so.

Relatively few of the studies discussed here actually compared methods of teaching at the elementary level. Most of them were concerned with the teachers of the elementary school, or with the training of high school students.

Since it appears to be of concern to modern science that scientific methods be learned at an early age, the present study is being presented in an effort to determine whether this scientific method can actually be learned and utilized more efficiently in the elementary school.

PROCEDURE

The investigator wrote units of study in the form of lesson plans for each of the topics to be covered, see Appendix A. The objectives, possible questions for discussion, and vocabulary terms essential to complete understanding of the topic were listed for use by all teachers. The lesson plans and presentation differed according to the method to be taught.

Factual material to be learned in both methods was gleaned from the Hillsborough Township Course of Study in Science for the fourth grades. This course of study is divided into six units: animals, plants, the universe, weather, the earth, and matter and energy.

A test to be given before and after each topic was also written. Questions for these tests were written through careful examination and comparison with those categories set up by Bloom.[60] Approximately seventy-five questions were written for each topic utilizing only the first three categories of Bloom's taxonomy,[61] i.e. recall, understanding, and application. All questions were carefully scrutinized by science teachers taking graduate courses at Rutgers University. In this manner, each topic was narrowed down to twenty questions divided among the three categories, see Appendix B. These were made into tests and administered to the fourth grades of Montgomery Township Public Schools for the purpose of checking reliability.

---

[60] Benjamin S. Bloom, ed., *Taxonomy of Educational Objectives, Handbook I: Cognitive Domain,* (New York: David McKay Company, Inc., 1950) 207p.

[61] *Ibid.* pp.62-143.

The recitation-demonstration method has previously been mentioned on page 9. Many, if not all, of the demonstration were presented by the students, however, this was at the descretion of the teacher. The textbook was used as a guide with specific assignments given from the text. All classes were expected to use many other books in addition to the text. After reading, question and answer periods were held, along with general discussion of the material presented.

In the project-research method the general problem presented to the class served as the class project, which the students themselves, guided by the teacher, theorized how to solve and set about doing so. Research in many books was used to help reach a solution. It might be pointed out that solutions reached by the students were not always the ones anticipated by the investigator.

From September to January the students in this group received some training in how to solve problems. This was accomplished by allowing the students to offer hypotheses to the problems given. The teachers did not say, "No, that will not work," but instead talked with the students, having them decide how to do things suggested.[62]

The inquiry training method of Suchman[63] was also used with modification. Suchman used silent film clips illustrating physical changes. The classes, in an effort to find out why the change took place, had to ask questions to be answered "yes" or "no". If questions were asked which could not be answered in this manner, the teacher indicated that more information was needed. In this manner, the students had to think clearly in order to phrase their questions properly. Half of the class served as questioners while the other half served as observers and evaluators.

In this study film clips were not available. Three demonstrations were performed by the teacher without comment. The procedure was then followed as above. The demonstrations were bimetallic strip which bends when heated; ball and ring which enables the ball to pass through the ring when cold but not when heated; plumbers sink pumps for air pressure. This last is a modern version of the Magdeburg hemispheres.[64]

---

[62] Robert E. Kilburn, "Hypothesis Testing: A Student Activity Approach," The Science Teacher 30 (November, 1963) 51,53.
J. Myron Atkin, "A Study of Formulating and Suggesting Tests for Hypotheses in Elementary School Science Learning Experiences," Science Education 42 (December, 1958) 414-422.
Arnold M. Lahti, "Scientific Methodology - The Education for a Changing World," Science Education 47 (March, 1963) 157-162.

[63] J. Richard Suchman, "Inquiry Training in the Elementary School," The Science Teacher 27 (November, 1957) 339+.

Training in observation was another point to be covered. When we observe anything, all five senses should be used. Children tend to use their eyes only unless some outstanding odor or sound is apparent. The use of all five senses was brought about through a game of sorts. Objects were placed within paper bags or boxes. Students could not see them and had to use other senses to assist in identifying the hidden objects. Teachers placed objects inside sealed boxes. The students were allowed to look at, hold, shake, and listen to the boxes, but could not open them. Students must observe through all their senses, recall past experiences, relate it to what is at hand,[65] and try to determine what is inside the box.

Dr. Karplus's Mr. O., an artificial observer, has brought out relativeness of observations.[66] This article was read by the teachers and discussed with the investigator so it was understood what was to be done in the classroom.

---

[64] Kenneth M. Swezey, "Classic Experiments in Modern Dress," Science and Children 3 (October, 1965) 6-9.

[65] Harry Milgrom, "What materials for Science Teaching," Science and Children 1 (September, 1963) 20.

[66] Robert Karplus, "Meet Mr. O," Science and Children 1 (November, 1963) 19-24.

The sample

The sample consisted of the fourth grade students in the Hillsborough Township Public Schools. Four schools were involved. One class in each school was taught by the recitation-demonstration method. Another class in each school was taught by the project-research method. The remaining classes were taught by the project-research method with the addition of an individual project which was done within the classroom. The purpose of this was to determine the effect of the extra time element allowed to those students performing the individual projects.

Through random sampling, classes in each school were selected for specific methods to be followed. Students had been placed in classes previously by the administration and could not be altered, making statistical adjustment highly probable.

The investigator met with the principals of all schools involved, individually, explaining the entire study to them and answering their questions. A second meeting was held at which the principals and the elementary supervisor were present. Again, questions were answered, the study discussed, and specific times set up to meet the fourth grade teachers.

Two meetings of approximately one hour each were held in each school with the fourth grade teachers of that school. At these meetings, the study as a whole was explained, as well as the part each teacher would play. Plans for the first topic were discussed and lesson plans given to the teachers. Times were set up for administration of the first standardized tests.

From the school office records, the birthdate, Kuhlmann Anderson I.Q. scores and father's occupation were obtained.

The Sequential Tests of Educational Progress (STEP) obtained from Educational Testing Service, science form 4 evaluate problem solving ability by having students define a problem; suggest hypotheses; choose correct procedures to follow; and draw conclusions.[67] Form 4A was administered to all subjects by the investigator. Form 4B was administered in June by the investigator. These tests were hand scored by the investigator and checked by a third party.

At the first testing; the pre test for the first topic was given to the teachers. Topic tests were given to the classes by their respective teachers. All test sheets and answer sheets were collected. At no time were

---

67. Sequential Tests of Educational Progress, Teacher's Guide, (Princeton, New Jersey: Educational Testing Service, 1959) p.72.

answers given to the teachers for the pre tests. Distribution of the post tests took place as teachers were ready for them, accompanied by the pre test and lesson plans for the following topic. After all answer sheets were in the hands of the investigator, correct answers were supplied for the post tests. This permitted the teachers to review the unit. All answer sheets were hand scored by the investigator and checked by a third party for accuracy.

The Iowa Tests of Basic Skills are an integral part of the Hillsborough Township School records. They are administered every year in October and scored by machine. The results were recorded as soon as received by the school system. All phases of these scores were recorded, although, at the present time, there are no plans to use anything but the grade average scores and the work-study skills section. These scores were taken during the fourth grade and again when these students were in the fifth grade.

In January, at the request of the administration, the investigator spoke to the classes that were to engage in individual research projects, answering questions and determining what equipment might be necessary. Equipment was ordered by the investigator as needed by the students.

Each student maintained a notebook of all information pertaining to his research and wrote a final report at the end of his work.

Throughout the entire year, the investigator was at each of the schools once a week, occasionally more often, to insure that teachers were following instructions and to give assistance whenever needed. In addition to passing out and collecting tests and answer sheets, extra library books were supplied to each school to be used by the fourth grade classes in this study. Books pertaining to each topic were supplied at the time the topic was studied. These books were chosen at various reading levels to accomodate the different levels of reading usually found at all grade level.[68]

As various data was collected, it was recorded on a separate data sheet for each student involved. This data sheet is shown in Figure 1.

---

[68] Books were supplied in almost unlimited number for an unlimited time by The Rutgers University Library (Juvenile Section), The New Brunswick Public Library, and the Somerville Public Library. The Somerset County Library supplied books for a one month time limit.

Name

School Teacher Method

Birthdate Age

Father's Occupation Kuhlmann-Anderson I.Q.

Iowa Tests of Basic Skills

1965												
1966												
year	Voc	Rdg	Sp	Cap	Punc	Use	Tot Lang	Maps	Graphs	Ref.	Tot Work Study	

1965				
1966				
year	Arith Con.	Arith Prob.	Arith Tot	Composite

Topic Tests

Post	1	2	3	T	1	2	3	T	1	2	3	T	1	2	3	T	1	2	3	T	1	2	3	T
Pre																								
	Plants				Earth				Matter				Universe				Weather				Animals			
1-Recall; 2-Comprehension; 3-Application; T-Total																								

STEP Tests

Sept.		
Jan.		
June		
	Raw Score	Converted Score

Figure 1

ANALYSIS OF DATA

The unit tests were analyzed by variance to determine their reliability.[69] This analysis is summarized in Table 1. Using the formula for reliability coefficient[70]

$$r = 1 - \frac{V_e}{V_{ind}}$$

the following values were obtained for r: Plants .816; Matter and Energy .880; Earth .704; Animals .768; Weather .772; and The Universe .710.

To determine whether differences existed between groups at the beginning of the study, data for age, grade average achievement, and intelligence test scores for all classes were analyzed in the computer using BMD01V - Analysis of Variance for One-Way Design - Version of January 8, 1964.

Table 2 shows the results of this analysis for the age group. No significant difference was found between the groups with respect to age.

The results of this analysis for the data on grade average achievement is shown in Table 3. A difference between the groups at the .05 level of significance was found.

---

[69] Fred N. Kerlinger, "Reliability," in Foundations of Behavioral Research. (New York: Holt Rinehart and Winston, Inc., 1965) pp.429-443.

[70] *Ibid.* p436.

TABLE 1

ANALYSIS OF VARIANCE OF UNIT TESTS

Source	d.f.	s.s.	m.s.
Plants			
items	19	12.3	.65
individuals	21	1.1	.052
residual	399	38.54	.077
total	439	51.94	
Matter and Energy			
items	19	11.94	.63
individuals	23	4.65	.20
residual	437	19.31	.044
total	479	35.90	
Earth			
items	19	16.5	.87
individuals	23	6.7	.29
residual	437	37.7	.086
total	479	60.9	
Animals			
items	19	13.4	.705
individuals	23	7.4	.321
residual	437	31.6	.072
total	479	52.4	
Weather			
items	19	9.2	.484
individuals	23	4.8	.208
residual	437	20.8	.048
total	479	34.8	
Universe			
items	19	17.8	.937
individuals	22	5.6	.254
residual	418	30.9	.074
total	459	54.3	

TABLE 2

ANALYSIS OF VARIANCE FOR AGE

Source	d.f.	s.s.	m.s.	F
between groups	10	3.0093	0.3009	1.4191*
within groups	206	43.6824	0.2121	
total	216	46.6917		

* Not significant.

TABLE 3

ANALYSIS OF VARIANCE FOR ACHIEVEMENT SCORES

Source	d.f.	s.s.	m.s.	F
between groups	10	24.2057	2.4206	2.5999*
within groups	206	191.7942	0.9310	
total	216	215.9999		

* .05 Level of significance.

TABLE 4

ANALYSIS OF VARIANCE FOR I.Q. SCORES

Source	d.f.	s.s.	m.s.	F
between groups	10	6149.0357	614.9036	3.4594*
within groups	206	36616.6012	177.7505	
total	216	42765.6372		

* .01 Level of significance.

Table 4 shows a difference at the .01 level of significance with respect to intelligence test scores.

The significant differences found between the classes on achievement scores and intelligence test scores indicated the need for covariance to be used with the remaining data to adjust for these differences.

The topic test scores, STEP test scores, and work study skills scores were analyzed using the program Analysis of Variance/Covariance - January 1965 Brigham Young University Computer Research Center. Since this program was unable to cope with a missing cell, it was decided to eliminate the one school containing that cell and use a 3 x 3 x 2 factorial analysis which is accomplished through the use of this program. Differences due to schools, methods, and sex were obtained through one analysis.

Each set of data was processed twice; the first time using I.Q. scores as the covariate, the second time using achievement scores as the covariate. Essentially the same results were obtained using the two covariates, indicating a high correlation between intelligence test scores and achievement scores.

Very highly significant differences are shown between methods in Tables 5 and 6 which show the analysis for topic tests on subject matter. These tables also

TABLE 5

ANALYSIS OF COVARIANCE FOR TOPIC TEST SCORES USING I.Q. SCORES AS A CONTROL

Source	d.f.	s.s.	m.s.	F
A Sex	1	1.4226	1.4226	.21
B Method	2	826.4791	413.2396	61.3 *
AB	2	24.5818	12.2909	1.83
C School	2	571.7631	285.8816	42.4 *
AC	2	12.3806	6.1903	.92
BC	4	767.9611	191.9903	28.5 *
ABC	4	20.5571	5.1393	.75
Error	161	1085.5161	6.7423	

* .001 Level of significance.

TABLE 6

ANALYSIS OF COVARIANCE FOR TOPIC TEST SCORES USING ACHIEVEMENT SCORES AS A CONTROL

Source	d.f.	s.s.	m.s.	F
A Sex	1	1.1182	1.1182	.17
B Method	2	776.8094	388.4047	59.6 *
AB	2	28.1670	14.0835	2.15
C School	2	546.9906	273.4953	41.8 *
AC	2	15.9057	7.9528	1.22
BC	4	740.4643	185.1161	28.3 *
ABC	4	18.2561	4.5640	.69
Error	161	1051.7828	6.5328	

* .001 Level of significance

show a highly significant difference between schools as well as the interaction between the two.

The converted scores of the STEP tests were used. The differences between scores obtained in September, 1965 and June, 1966 were analyzed by covariance as previously stated. Tables 7 and 8 show the results of this analysis. There are no significant differences for any of the F values, although there is some difference with regard to sex.

The increase in work study skills as determined by the increase in scores on Work Study Skills section of the Iowa Tests of Basic Skills from the beginning of the study and scores from the same tests taken one year later indicated no significant differences between groups. This analysis is shown in Tables 9 and 10.

TABLE 7

ANALYSIS OF COVARIANCE FOR STEP TESTS USING I.Q. SCORES AS A CONTROL

Source	d.f.	s.s.	m.s.	F*
A Sex	1	36.0676	36.0676	3.37
B Method	2	6.5846	3.2923	.306
AB	2	4.6797	2.3399	.218
C School	2	11.0686	5.5343	.515
AC	2	.9385	.4693	.044
BC	4	53.1412	13.2853	1.24
ABC	4	46.5658	11.6415	1.085
Error	161	1727.9034	10.7323	

* Not significant.

TABLE 8

ANALYSIS OF COVARIANCE FOR STEP TESTS USING ACHIEVEMENT SCORES AS A CONTROL

Source	d.f.	s.s.	m.s.	F*
A Sex	1	30.8649	30.8649	2.68
B Method	2	16.6254	8.3127	.723
AB	2	7.5234	3.7617	.327
C School	2	17.0131	8.5066	.740
AC	2	5.4186	2.7093	.235
BC	4	54.3912	13.5978	1.18
ABC	4	46.4631	11.6158	1.01
Error	161	1853.9025	11.5149	

* Not significant.

TABLE 9

ANALYSIS OF COVARIANCE FOR WORK STUDY SKILLS USING I.Q. SCORES AS A CONTROL

Source	d.f.	s.s.	m.s.	F*
A Schools	2	21.8576	10.9288	2.51
B Methods	2	4.0209	2.0105	.46
AB	4	25.7131	6.4283	1.48
C Sex	1	.9740	.9740	.22
AC	2	9.1397	4.5699	1.05
BC	2	22.2698	11.1349	2.61
ABC	4	9.1559	2.2890	.53
Error	148	644.2270	4.3529	

* Not significant.

TABLE 10

ANALYSIS OF COVARIANCE FOR WORK STUDY SKILLS USING ACHIEVEMENT SCORES AS A CONTROL

Source	d.f.	s.s.	m.s.	F*
A Schools	2	25.1871	12.5936	2.86
B Methods	2	2.3985	1.1992	.27
AB	4	28.4521	7.1130	1.61
C Sex	1	3.0526	3.0526	.69
AC	2	11.4889	5.7444	1.31
BC	2	19.8966	9.9483	2.26
ABC	4	10.6493	2.6623	.606
Error	148	651.8774	4.4046	

* Not significant.

CONCLUSIONS

Since a reliability of .7 is reportedly good for subject matter testing, the unit tests were left in this form for use throughout the study.

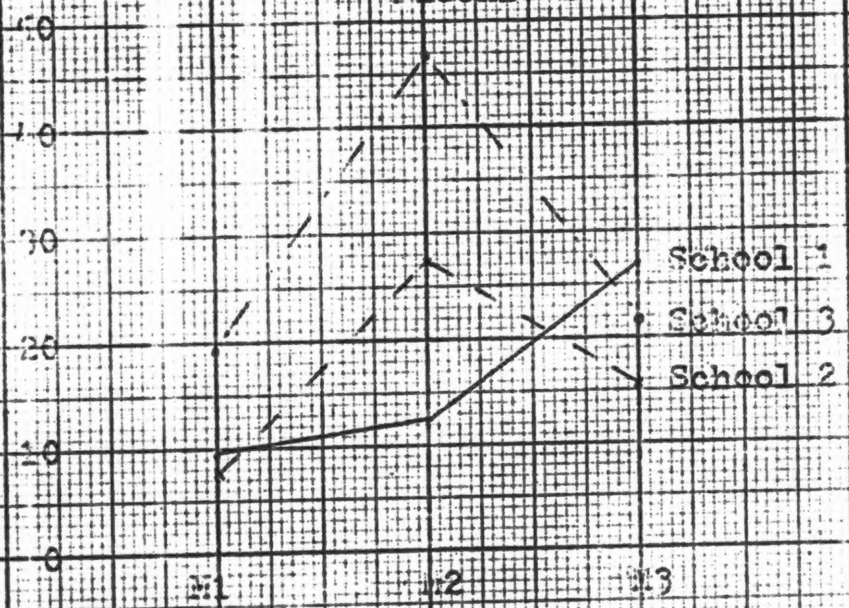
The analysis of I.Q. scores and achievement scores for the classes at the beginning of the study showed a significant difference at the .01 and .05 levels of significance respectively. This made an analysis of covariance necessary to adjust statistically for these initial differences.

In studying the analysis of subject matter acquisition, an extremely significant difference was found between methods, schools, and the interaction of the two, indicating that more is involved in learning the subject matter than the method by which it is taught.

Figure 2 shows the gain in scores of unit tests by school and method as adjusted for achievement as the covariate. Two of the schools show a marked difference between the recitation demonstration (M1) and the project research, without individual projects (M2).

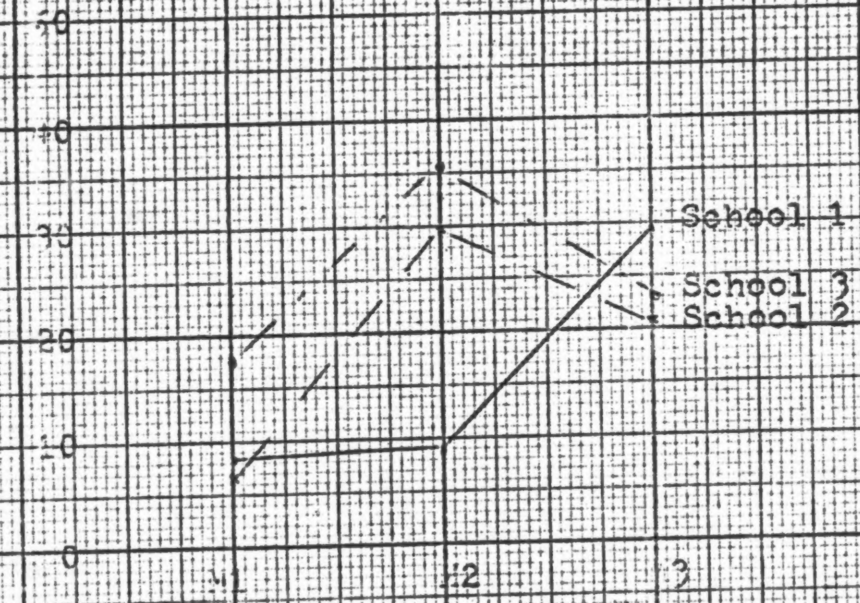
Both of these schools show the groups without projects being superior to the groups with individual projects (M3), however, both groups in the project-research method are better than the recitation-demonstration.

FIGURE 2



Acquisition of Subject Matter
Achievement as covariate

FIGURE 3



Acquisition of Subject Matter
I.Q. as Covariate

EUGENE DIETZGEN CO.

In the third school the project-research group without projects did only slightly better than the recitation-demonstration, while the group with individual projects was far superior.

Figure 3 shows the same relationship of scores to schools and methods. This time, it is adjusted for I.Q. as the covariate. This adjustment appears to be more adequate than that of achievement. The same results are obtained, however.

This might be an indication that most students of this age are not prepared for independent projects, although it appears that the group projects are well worthwhile.

In looking at the differences within schools, the possibility that the teacher of method 2 school 1 could have been preoccupied with cares of the school presents itself. This is the only teacher in the study who, while not designated as a building principal, was in charge of the school building in addition to the regular teaching tasks. It would be interesting to study the effects that teachers of this sort have as compared to teachers without administrative duties.

The null hypothesis that there was no difference between methods on the acquisition of subject matter knowledge was rejected.

The problem solving ability of the students showed no significant differences in any respect, upholding the null hypothesis originally presented that there would be no difference between the methods.

When problem solving ability was looked at with specific reference to sex, a difference was noted in favor of the male sex, but this difference was not significant.

Analysis of the Work Study Skills section of the Iowa Tests also showed no significant differences. The null hypothesis was, therefore, upheld in this instance too. A difference was found in the acquisition of work study skills between the schools involved in the study. This was not significant, however.

At the onset of the study, the groups were to be divided into high, middle, and low based on intelligence scores. As it worked out, this would leave several cells empty. As reported earlier, the program cannot accomodate these empty cells. Another grouping was tried, and this too ran into empty cell problems. This resulted in an inadequate testing of this particular null hypothesis. All students gained, regardless of which method they were taught. The more intelligent students gained more than the low intelligent students regardless of which method was involved, but an actual statistical test was not performed.

Since each analysis of covariance covered, took care of sex differences, this null hypothesis was also upheld.

The null hypotheses were all hpheld except that of subject matter acquisition. In this, the project-research method was extremely significantly superior. Before this conclusion can be extended as a generalization beyond Hillsborough Township Public Schools, the study should be repeated with a larger more random sample. An attempt to determine the differences due to schools should also be made.

More general problems to serve as group projects for the project-research method must be worked out before this method could be put into general practice even if future studies should uphold the findings of the present study.

Several unofficial, or at least non-statistical findings might make this method of teaching become more general. These findings were obtained from opinions of the students and teachers involved.

More students in the project-research method had a greater interest in science at the end of the study than they had at the beginning. Some of these students expressed the desire to continue working on problems of the sort they had been using in future years, more specifically in fifth grade. None of the students in the recitation-demonstration method showed this interest. Some even expressed a greater dislike of the subject.

The teachers using the project-research method liked the approach to the topics and favored the overall continuity of the problems. The investigator was asked by several of the teachers if they could use these problems in future years of teaching. These teachers found it easier to evaluate the progress of students and had less trouble maintaining the interest of the class.

APPENDIX A

Lesson Plans

GENERAL OBJECTIVES

Each student should be able to:

1. Recognize a problem.
2. Suggest possible solutions to a known problem. (Hypothesize)
3. Recall certain facts.
4. Understand these facts.
5. Apply these facts in similar situations.
6. Use some tools of science. (Accurate observations - measuring; accurate recording of data.)
7. Construct an experiment to test a hypothesis they might have.
8. Organize data.
9. Select data which is pertinent to a problem. (Relationship.)
10. Evaluate the source of authority.
11. Use the vocabulary of science correctly.

Objectives 3, 4, 5, and 11 will be tested for by a twenty question multiple choice test for each topic of study.

Objectives 1, 2, 6, 7, 8, 9, and 10 will be tested for by the STEP tests of science for fourth grade.

There are six topics. Each topic is allotted six weeks time. The topics are set up as 12 lessons of 45 minutes each. This may be changed to 18 lessons of 30 minutes each for the purpose of scheduling and adjusting to the attention span of the students.

Because of time taken with official school use, some of the topics were cut to 10 lessons taking five weeks instead of the six weeks originally planned for.

Project-Research

Training in observation:
Odor: Place one item in a small box with holes punched on top. Have student identify contents from odor only. Additional items may be added to the list. These are just suggestions: Banana, onion, orange, lemon, tuna fish, flowers-lilac, rose, marigold.

Sight: Place 20 objects (small) on a tray. View for one minute. Have students list as many objects as they can remember.

Place 20 objects on a tray. View for one minute. Turn and remove one from the tray. Students look for another minute. Which item is missing?

Send one person from the room on an errand. Ask the class - What color shirt did he have on? etc.

Feel or Touch: Place small objects in paper bags. Have students feel the object through the bag and identify it - on paper so that more than one can have a chance at each object.

Combination: Place an object in a box and seal the box shut. Student tries to determine what is in box by - size of box; weight of box; sound it makes when shaken. Does object slide or roll from one end to the other. After some practice, try putting two or three objects in the box.

Give one candle to a group of three or four students. Have them list as many things as they can observe about it. Before and after it is lit.

Perspective: This uses Dr. Karplus's concept of Mr. O. Mr. O has no emotions. He reports only what he sees. Mr. O rides on a truck which goes from the front to the back of the room. Mr. O in the truck says he has not moved (He is still in the truck where he started.) Mr. O sitting at a desk says he has moved, because the truck is in a different place and the first Mr. O moved with the truck.

Similar situations should be set up - shows that things do not always appear the same when seen from different points of view.

Training in Inquiry:

From Dr. Suchman's work. A short experiment is performed by the teacher. The class is to determine why certain results were obtained. They may ask questions of the teacher, but these questions must be answered by yes or no.. This gives the students practice in deeper thinking and formulating their hypotheses before asking questions. If a question cannot be answered yes or no, the teacher should simply say, "I cannot answer your question." Have only half of the class questioning at each experiment, the other half acting as observers. Reverse halves for the next experiment. Do three: Bimetallic strip - bends when heated;; Ball and ring - ball will go through ring, when heated it will not go through ring; Plumbers sink pumps - air pressure holds them together.

Project-Research

The following lesson plans are only guides for the teachers use. Once the problem has been presented to the class, they should be allowed as much freedom as possible to solve the problem. However, they will need considerable guidance from the teacher. Lesson plans are given according to the way the writer thinks the students should work. Your class might come up with an entirely different viewpoint, which would still solve the problem. Do not force the class to follow.

Any experiment that students suggest to test an idea involving the solution to the problem should be tried in as far as time and equipment are available.

PLANTS

Objectives:

1. To understand simple means of classification.
2. To understand the terminology.
3. To learn the methods by which plants reproduce.

Vocabulary:

1. root
2. stem
3. leaf
4. flower
5. seed
6. fruit
7. petal
8. stamen
9. pistil
10. bud
11. soil
12. water
13. annual
14. biennial
15. perennial
16. sepal
17. spore
18. humus
19. mulch
20. fungi
21. pollen
22. fertilizer
23. nectar
24. ovule
25. loam
26. bulb
27. taxonomy
28. botanist
29. horticulturist
30. agronomist
31. conservation
32. environment
33. photosynthesis
34. germinate
35. bacteria

Questions:

1. Why is pollen so important to plants?
2. How are insects useful to plants?
3. Why are the color and odor of flowers so important to them?
4. Can a garden grow well with any plant? Explain why or why not.
5. What part(s) of plants do we eat? List the names of several plants under each part you name.
6. In what ways are plants necessary to man?
7. Where do plants get their food?
8. Name four ways in which plants reproduce themselves. List names of plants under each way.
9. In what ways do plants insure (protect) themselves in order to live and reproduce?

Taxonomy:

Thallophytes	Fungi	No chlorophyl, spores or budding yeast, mold, mushrooms, bacteria, toadstools.
	Algae	Green, simplest plant, lives in water, split(cell division). pond scum.
Bryophytes	Mosses	Shallow roots, leafy part produces spores.
Tracheophytes		
Pteridophytes	Ferns	Roots, stems, leaves; spores.
Gymnospermae	Ferns	Same, but seed producing.
	Conifers	Evergreen trees - seed producers.
Angiospermae	Flowering Plants	Monocotyledon - one section of food in the seed. Bulbs, corn.
		Dicotyledon - two sections of food in the seed. Lima bean.

Recitation-Demonstration
Lesson Plans

1. Pretest. Assignment: Read pages 276-283 in text.

2. Discuss plants and parts of plants - roots, stems, leaves, flowers, seeds, fruits. Have student draw parts on board as discussed. Follow up by having real plant pulled apart to show the different parts. (Possibly a chart could be made on paper showing drawing and real parts.) Written assignment: Find out what each part does for the plant.

3. Collect assignment. Seeds. Have lima beans for each to pull apart. Discuss the three parts - plant, food, protective cover. DEMONSTRATION: Have two students plant several beans in glass jar with blotter -to watch development. Observe growth each day. Discuss use of each part of the seed. Assignment: Look up meaning and use in sentences, ten words from the vocabulary list.

4. Discuss assignments from lesson 2. Question and answer period from the first reading assignment. Parts of flower - petal, sepal, stamen, pistil, pollen. Make drawings at board as for plant parts. Question - Is there a purpose for each part? Find out. Written assignment. Also assign a demonstration to a student - celery stalk in half - red ink and blue ink - shows function of a stem.

5. Collect and discuss assignment. Have demonstration. Teacher will mention photosynthesis as process of making food. Assignment - additional ten words from vocabulary.

6. Function of parts reviewed in discussion of how plants make food. Roots get materials from soil, stems carry it to leaves, leaves take carbon dioxide from air and manufacture food (photosynthesis), stems carry food to rest of plant. Minerals, water carbon dioxide (CO_2) and sunlight necessary.
Assignment: Finish vocabulary words.

7. Have students make bulletin board showing parts and function of plants. (This could be done using charts previously made, or from menory as a means of evaluation.) Assignment: Read pages 264-275 and 283-286.

8. Discuss questions. Add those of students which may not be on chart. See whether some have already been answered in class discussion. Start them answering in complete sentences to be turned in at a later date.

9. Discuss assignment from Lesson 7. How plants reproduce. Have bulbs (iris or tulip), roots (grass, strawberry), seeds (zinnia), stems (geranium) on hand for examination. Continue discussion with how seeds are spread - wind, animals; and how they protect themselves. Student assignment: Demonstration - of how burdocks stick to clothing animals, etc. Wind blows dandelions. Assignment - continue working on questions.

10. Adaptability of plants. Cacti - desert, etc. Refer back to reading assignment. Discussion. Also point out relation of this to crops grown in various places to be studied in Social Studies. Uses of plants by man. Particular attention to classroom uses - desk - trees; doors - trees; clothes - cotton (wool is from animal). Assignment: Find out what conservation is.

11. Collect and discuss assignment. Discuss need for replanting etc. General review of unit. Question and answer period.

12. Post test.

Project-Research
Lesson Plans

1. Pre test.

2. Present problem to class. You have a large number of plants and are expected to learn all about them. How would you go about making the problem easier to handle? Let students make suggestions and list them on the board. Preliminary work should be set up together. Various suggestions should be discussed and how they might go about following these suggestions.

3. The actual plants should be presented to the class. They can then proceed to sort them out according to various hypotheses they have made in the previous lesson. The class should come to the conclusion that some means of dividing them into groups would make it easier.

4. If the group did not decide to divide, the teacher should make an analogy (reading groups make it easier to teach reading.) Steer them towards the functions of various parts as a means of division. The discussion of roots should give someone the idea of sorting those plants without roots (mushrooms) into a separate class, and question how they obtain their food.

5. Reading period (Library, if possible). This time should be spent looking through books on plants and reading about them. The length of the period must be adjusted by the teacher.

6. Root systems considered as a major means of classification of green plants. (Most bulb and root growers do not bear seeds: no roots - spores, seed bearers) etc.

7. Adaptability and ways of protection can also be used as a means of classification. They should be mentioned (if the students have not come up with the idea on their own), considered and used as alternates to whatever the students have been working on.

8. The uses of these various plants can be portrayed in an individual notebook designed by the students. Conservation should be brought in. Ways of solving the original problem should be written up in the notebook.

9. Without changing anything in their notebooks, the true taxonomy of botany should be presented and compared with whatever the students have come up with in their effort to learn all about plants.

10. Discussion of questions used in Recitation-Demonstration.

11. Students summarize what they have learned about classification of plants; ask and answer questions. General review.

12. Post test.

THE EARTH

Vocabulary:

1. land
2. plain
3. desert
4. mountain
5. rocks
6. soil
7. valleys
8. islands
9. glacier
10. volcano
11. ocean
12. pond
13. lake
14. swamp
15. stream
16. river
17. fossil
18. geyser
19. atmosphere
20. troposphere
21. stratosphere
22. ionosphere
23. irrigate
24. forests
25. resource
26. sphere
27. gravity
28. plateaus
29. fresh (water)
30. shale
31. erosion
32. limestone
33. mineral
34. ore
35. porous
36. mantle
37. crust
38. core
39. earthquake

Questions:

1. What is the earth made of?
2. What are the things that change the earth's surface? How do they do it?
3. How does the earth fit into the solar system?
4. Why is our year 365¼ days long?
5. What do we mean when we say "up" or "down"?
6. Why is the United States divided into time zones? Why aren't these boundaries straight?
7. What is the atmosphere? Is it part of the earth?

Much of this ties in with the study of the continents and oceans of Social Studies. Do not hesitate to make the comparison.

Objectives:

1. To understand the general make up of the earth, i.e. its three basic parts.
2. To understand the processes of erosion and mountain building.
3. To understand the importance of each of the three basic parts of the earth.

Recitation-Demonstration Lesson Plans

1. Pre test.

2. Discussion on earth's place in the Universe. Seasons, and day and night. Assignment: Read pages 1-25 Exploring in Science.

3. Three parts of the earth: The air (gaseous part). Go over the three layers of the atmosphere. Demonstration - make rain. Normal pressure of air (14.7 pounds per square inch.) Stack 15 pounds of books. Let everyone pick the stack up to get the idea of how much it really is. Discuss why we don't feel it as that much on our bodies. (The pressure inside is the same as on the outside.) Assignment: Read pages 54-75 Exploring in Science. Have demonstration of the siphon.

4. Question and answer period on assignment. Demonstration assigned. Discussion of the various gases in air. Nitrogen - 79%, inactive; Oxygen - 20%, needed by animals to live, needed for fire to burn, plants exhale it; Carbon Dioxide - .3%, animals exhale it, plants need it to make food, puts out fires.

5. Water (Liquid part of the earth). Salt water bodies - oceans, seas, some lakes (Salt Lake, Utah). Salt is not the same as that we eat. Various salts from different places - carried from land to the ocean. Liquid evaporates, leaving the solids behind. Assignment - Begin work on vacabulary words.

6. Fresh water bodies - streams, rivers, ponds, lakes, swamps. Water runs downhill carrying salts and dirt to the ocean. Not enough of the salts to make this water salty, but it accumulates in the oceans. Demonstration - erosion of soil by running water. Assignment - Read pages 188-213 in regular text. Also find out where your water comes from: if it comes from well - how deep is it? (Most of the homes here have wells. Those in the newer developments have water systems.)

7. Discussion of various well depths. Have various students demonstrate in the aquarium - filter page 209; swamp pages 198-99; water hole and well pages 194-95; and lake page 197.

8. Movie - The Restless Sea. (The story of water as told by a drop of water.)

9. Discussion of film. Begin land (solid part of earth) ¼ surface of earth is land. Glaciers cover part of this (North and South Poles). Formation of glaciers.

10. Mountains - valleys, hills are all various heights of land. All formed of rocks and minerals. Assignment: Read pages 244-266 Exploring in Science. Soil is broken up rock. Have several students make soil by rubbing rocks together. Note the time involved and discuss the time in nature (many years for soil to form.

11. Formation of a mountain. Forces pushing against rock. Rock must move - it goes up. General review.

12. Post test

Project-Research
Lesson Plans

1. Pre test

2. The earth's surface has not always been the way we know it today. At one time, the Appalachian Mountains were under the sea and the part of New Jersey that we live in was once part of a mountain instead of a plain. How did these changes come about on the earth's surface and how do we know these things? Allow time for discussion. Find out what the earth is made of.

3. Discussion on what the earth is made of. Gaseous part (air); liquid part (water); solid part (land). Air in form of wind can move soil from one place to another (Playground on a windy day.) Water moves things from one place to another. Small particles of solid are carried with the running water. Let class devise a means of showing this (erosion) as homework. Water also puts some things into solution and carries them along. Have them try dissolving rocks of different types. Ask the children to bring in rocks.

4. Air. Does it cause any changes in the earth. Oxygen unites with iron to give rust. Carbon dioxide and water vapor also react (chemically) with some of the minerals. Have some of the students show how they worked out the erosion problem. Air and water in the soil work much the same changes.

5. They are all changes made on or very close to the surface. What changes might take place underneath the surface. (Compare to a pileup on the football field. What happens to the man on the bottom?) Same pressures on soil, but it can't holler. Pressure turns the soil into rocks. Pressure continues even after there is solid rock. Assignments - Think of some way to demonstrate this pressure. Pressure in all directions (Hone, page 112). This is the beginning of mountain building.

6. Volcanoes and earthquakes (Movie with this name is excellent.) How pressure moves the earth to form these two. Comparison of erosion cycle (mountain of solid rock - broken down, erodes to bottom, soil, soil piles up, pressure causes new mountain formation. This takes many thousands of years. Water cycle a short time.

7. Fresh and salt water bodies and how they got that way. Drilling for water, water table - porous and nonporous substances.

8. Movie - The Restless Sea - (The story of water as told by a drop of water.)

9. Discussion of film. Glaciers (solid water) erodes same as stream only slower. Carries larger solid particles with it. Comparison of glacier and mountain formation. Glacier formed (like rocks) from pressure on piled up snow. Excess pressure, causes erosion downhill rather than to form mountain.

10. How do we know this happened? Noone has written about it. It takes so long that noone has been able to watch it. Fossils of sea animals and plants found at top of mountains.

11. Discussion of how man changes the surface. Bulldozers. Plowing land, leaving it open to erosion. Question and answer period. General review.

12. Post test.

MATTER AND ENERGY

Objectives:

1. To understand the three phases of matter.
2. To understand the similarities and differences between the three stages.
3. To understand that energy has different forms: heat, sound, light, electricity, and magnetism.

Vocabulary:

1. matter
2. energy
3. transform
4. electricity
5. current
6. generate
7. switch
8. insulation
9. insulator
10. conductor
11. magnet
12. attract
13. repel
14. pole
15. electromagnet
16. light
17. sound
18. vibrate
19. density
20. fuse
21. wave
22. heat
23. chemical
24. Mechanical
25. prism
26. spectrum
27. friction
28. lubricate
29. velocity
30. circuit
31. compression
32. transmit

Questions:

1. What causes light to bend?
2. How are magnetism and electricity alike?
3. Why is insulation on wires so important?
4. What causes the different tones on an xylophone?
5. What is alternating current? direct current?

Recitation-Demonstration
Lesson Plans

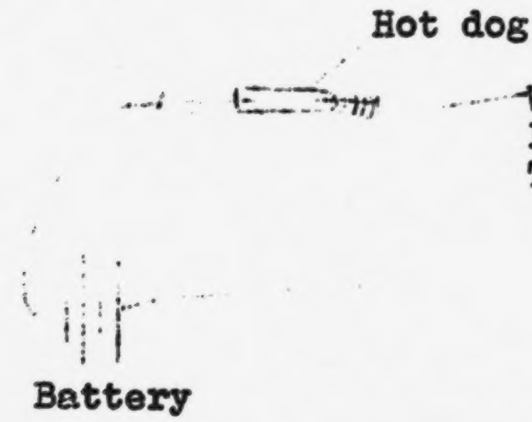
1. Pre test. What is matter? (anything that takes up space and has weight.) Students use dictionary and pick out correct meaning for a science lesson. Brief discussion of the three forms of matter - solid, liquid, gas.

2. Demonstrations. Ice cubes (solid) melted to water (liquid) boiled to steam (gas). Cannot create matter, only change its form. Matter can be changed into energy. What is energy? Again have students look it up (ability to do work.) Energy can be in the form of heat, chemical, physical. Muscles, wind, water, sun, electricity all do work, therefore have energy. Demonstration - windmill and waterwheel page 216-18 text. How have the wind and water done work? Assignment: Read pages 214-221.

3. Demonstration: Electric motor pages 222-223 text. Have a student explain how it works. Why is it necessary to turn current on and off all the time? (The magnet would attract and keep the motor still instead of turning as it should. A real motor does this too, but so quickly that it is not noticed - A.C. current.) Discussion of A.C. and D.C. currents. Alternating current shuts itself on and off as above. Direct current is continuous. This is found in dry cells. Assignment: vocabulary words.

4. Purpose of a switch (to complete or break a circuit.) Set up dry cell, switch and light. Rewire for a fuse (Hone page 382) and short the wires. (You can do this yourself, or have one of the students do it.) Discuss what happens and why. Discuss the need for insulation on wires (prevent short circuits and shocks). and need for fuse boxes or circuit breakers. A fuse box and circuit breaker serve the same purpose. Fuses, if burnt out need to be replaced, circuit breakers need only to be flipped back into place. Assignment: Read pages 223-238.

5. What is an insulator? a conductor? Have one student show various conductors to the class (a conductor is anything that will complete a circuit.) Another student can show insulators. (An insulator will not complete a circuit.) Ask students if they think a hot dog will be an insulator or a conductor. Proceed to cook the hot dog. Discuss relation of hot dog to man and what happens if man touches a live wire.



Wire coiled around nails
Push nails into hot dog.
Then connect battery.

6. Discussion of similarities between electricity and magnetism. (Both have poles, force of attraction and repulsion.) Magnetic force field - Demonstrate using magnet and iron filings. Strongest point of force at poles. Assignment: Read 128-135 Exploring in Science.

7. Temporary and permanent magnets. Temporary is an electromagnet. You made one as part of the electric motor. Compare the strength of the two. Static electricity and its relationship to electricity and magnetism. (It has poles, it is a build up of electrical charge; it can cause a shock when this is discharged.)

8. Light is a form of energy. It travels in straight lines. (Put a pencil in glass of water, what happens? Pencil appears to be cracked due to refraction of the light rays in water.) Use electricity to make light. Demonstration - simple electric lamp (Hone page 381). Heat produces light.
White light (as we know it) consists of different colors. Spectrum - Use a prism to show the spectrum (rainbow.) Assignment: Answer questions.

9. Sound is another form of energy, caused by vibration. Use a tuning fork. Strike it in air, then set it on wooden desk. What is the difference and why? (On the desk should be louder because the particles of wood are also vibrating to the same tune as the tuning fork.) Use glasses, or bottles, with different levels of water in them. Strike them gently. What is the difference. (The larger the column of air in the bottle or glass, the lower the note should be. If adjusted properly, tunes can be played on them.) General review and questioning.

10. Post test.

Project-Research
Lesson Plans

1. Pre test. Find out what matter, energy, and work are. Use dictionaries. Have one student walk across room carrying a pencil, another push hard against the wall of the room. Which is doing more work? Let them think about it.

2. The one carrying the pencil did more work - in the scientific sense of the word. Work is movement of something through some distance. Energy is used to do this work. Problem - How are all types of energy alike - sound, heat, light, electric? What makes sound? How can you hear what I am saying (vibration of air.) What makes sound different from one another (the number of vibrations.) Use tuning forks, two of same frequency and one of another frequency. Ask what will happen if one is set to vibrating. Let them think and work it out.

3. If tuning forks are set on top of same surface and one is struck, the second one of the same frequency should also start vibrating. The one with different frequency will not. This should also work if they are held close to one another in the air, but try it out first if you want to do it this way. Recall movie The Restless Sea. What happens to cork on the ocean waves? In same manner - sound moves by knocking into next molecule of matter. Compression (Hone page 234). Sound goes around things, that is, you can hear things in the next room.

4. Heat. Put pan of water on hot plate. What happens? Heat goes into pan then into water. Molecules of water move faster, hit one another. Heat in the hot plate causes light. Heat moves the air particles and they go all around. The light goes in straight line until it hits something. We found that sound goes around things. If we put an obstacle in front, can we still see? Why? (Light is reflected - bounces off solid things in straight lines - from solid things unless they are transparent.) What happens to sunlight when you use a prism. (It breaks up into colors - Wave lengths are different.)

5. Electricity - produced by wind, water, and fuel to run generator. Discuss uses of switches, what insulators and conductors are. (Switch used to complete or break a circuit. Insulator does not conduct electricity. Conductor is one through which current will flow.) Why do we have insulation on wires? (You might try to cook a hot dog as in Recitation-Demonstration.)

6. Discuss direct and alternating current. Houses are on A.C. Motors automatically cut on and off, pulsating current. It is so quick you cannot notice it. D.C. current is steady. Both push electrons through the wire and other items of the circuit. The circuit must be complete or the electrons do not flow.

7. Practical wiring of dry cells to work lights and bells, using switches and fuses (Hone page 382). Ask students to bring in dry cells (many of the boys have them.) Those who wire very quickly should be encouraged to try some in series or parallel, like Christmas tree lights.

8. Magnets - attraction and repulsion - size and shape. Poles. Show magnetic field using iron filings (Hone page 341) Also make and use an electromagnet (Hone page 352). Compare the strength of the two.

9. Relate the ways in which the different forms of energy are alike. All are one particle hitting the one next to it to move the energy along. It would be difficult to relate our own muscle energy to the level where it could be understood, but it too works on the same basic principle. General review and question and answer period.

10. Post test.

THE UNIVERSE

Objectives:

1. To understand the relationship of earth, sun, and moon.
2. To understand the effects of the sun and moon on the earth.
3. To understand the relationship of sun to time on the earth.
4. To understand the place of earth in the solar system.

Vocabulary:

1. astronomer
2. universe
3. star
4. planet
5. galaxy
6. centrifugal
7. gravity
8. season
9. axis
10. orbit
11. reflects
12. moon
13. sun
14. earth
15. tide
16. satellite
17. atmosphere
18. astrologist
19. rotate
20. asteroid
21. meteors
22. meteorite
23. equinox
24. astronaut
25. telescope
26. observatory
27. solar system
28. comet
29. Galileo
30. Isaac Newton

Questions:

1. How is it that we can tell time by the sun?
2. What causes us to have summer when the sun is farthest away from the earth?
3. Why is the moon so hot during the day and cold at night? Why isn't earth like that?
4. Why don't the planets shine in the same way stars do? Or do they?
5. Why doesn't the moon, and our artificial satellites, go flying off into space?
6. What instruments are used to study the universe? Tell about them.

Recitation-Demonstration
Lesson Plans

1. Pre test

2. Ask what the universe is made of. Have general discussion, listing on the board as things are mentioned. When someone mentions planets (or at end of general discussion) find out what they know with reference to the names, locations, and relative sizes. Assignment: Read pages 31-37.

3. Forces holding universe together - gravity and centrifugal. Discuss. How to measure force of gravity (scale). Might tie in with health weighings.) Bucket of water - upside down, gravity makes it spill out - BUT spin it around, centrifugal force prevents the water from spilling even when turned over. Use demonstration of experiment page 249. Assignment: Read pages 245-252.

4. Planets - reflect sunlight. Stars give off own light. Discussion of the difference. (Stars are burning gaseous masses.) Sun and moon rise and set. Demonstrations - sun, moon, earth. Use globe, ball, and light to show day and night. General discussion of day, night, and seasons.

5. Relative and actual size of earth, moon, and sun. Text page 253-256. Might want to read over IN class. Discussion of why moon changes shape. (Actually, it doesn't. It is only the part we see that changes). Demonstration page 258. Assignment: Read pages 257-261.

6. What is the moon like. Pictures of Ranger I and II, if available. Discuss what we have learned from them. Why is the moon hot during the day and cold during night. (Effect of atmosphere.) Assign additional vocabulary words.

7. Moons effect on the earth (tides). What happens? Why does it happen? Compare gravity of earth and moon. Discuss Galileo and Newton and the part they play in astronomy.

8. Relative numbers of stars and their distance away. Sun is nearest star. Milky Way as a galaxy and its relation with our solar system. Assignment: Answer questions. Due lesson 10.

9. Sun - Most important star to us. Gives earth most of the heat. Same effect as campfire - hot close up, cools off the farther away you get. Effect of atmosphere to slow sun's rays. Otherwise we would burn up. Finish vocabulary.

10. Use of the sun as a time piece. Bell Telephone Film. Have a demonstration of sundial on the playground. About Time.

11. General review. Go over vocabulary and questions. Discuss any questions students might have.

12. Post test.

Project-Research
Lesson Plans

1. Pre test.

2. Present problem: What would happen if the earth were to slow down so that it took one year to rotate on its axis instead of 24 hours. It stops slowing when it is 12 noon on July, 21st where you live. Discussion of how to decide. Try to bring class to the realization that an understanding of present conditions will give some basis for prediction.

3. The orbit of earth and the other planets. Discussion (art-can make model of the solar system). In class decide on size, shape, and color for each planet and sun. Use this with students carrying models to enact solar system movements. After discussion of orbits, make a tentative decision as to whether orbits would be effected. Be sure gravity and centrifugal force are brought into the discussion.

4. Sun and other stars. What makes them shine. Would there be any effect on them? Earth itself. What causes day and night? Why does the length of day and night change from summer to winter? Use models to reenact scene. Would there be any effect on day and night because of the change.

5. What causes the seasons? Would this be effected in any way? Discussion of earth and sun farthest apart in summer, yet it is warmer then, Why?

6. What is the air around the earth like? Would this be effected in any way? Is there air on the moon? How does this effect the moon and make it different from the earth?

7. What happens in the oceans all over the world? (tides) What makes this happen? Would there be any effect on oceans in our problem? If so, what?

8. Moon is a natural satellite. Does it move the same as earth? Would it be effected in any way by earth slowing down? What about artificial satellites and spaceships?

9. We have already discussed the effect on day, night, and seasons. How would this effect our time. Discussion of time determination. Assignment: Make a crossword puzzle using the vocabulary words.

10. Show Bell Telephone Film, About Time.

11. Summary of problem solutions. Teacher may tell students what experts think will happen. Be sure they understand that even the experts do not know what would actually happen. Go over crossword puzzles.

12. Post test.

WEATHER

Objectives:

1. To understand and be able to read some of the instruments used in determining the weather.
2. To understand what causes the different forms of precipitation.
3. To understand the effects of various types of earth surfaces on the weather.

Vocabulary:

1. weather
2. climate
3. thermometer
4. barometer
5. wind vane
6. precipitation
7. anemometer
8. hygrometer
9. air mass
10. front
11. high
12. low
13. humidity
14. pressure
15. temperature
16. wind
17. cyclone
18. hurricane
19. tornado
20. blizzard
21. storm
22. rain
23. cloud
24. cirrus
25. nimbus
26. cumulus
27. troposphere
28. ionosphere
29. meteorology
30. stratosphere
31. meteorologist
32. snow
33. hail
34. sleet
35. evaporation
36. transpiration
37. dew
38. frost

Questions:

1. What is the significance of the high areas on a weather map? The low areas?
2. How does air pressure effect the weather? How is this pressure used in forecasting the weather?
3. What causes different types of storms to develop?
4. How is a weather map made?
5. What is meant by man-made weather?
6. What is the difference between water and water vapor?
7. What is the difference between cirrus and cumulus clouds?

Recitation-Demonstration
Lesson Plans

1. Pre test. Assignment: Read pages 49-52.

2. Heat - Effect of weather. Where does heat come from (Sun) and effect of day and night on weather. Demonstration - Globe and light to show day and night. Assignment: Weather terms to be learned, vocabulary - first part.

3. Learning to read the thermometer and barometer (Correlate with arithmetic, or review if already covered. Number line is especially good to use with barometers.) Discussion of freezing and boiling points. Have container of ice and one of boiling water, have temperature read in each. Do together or separately. Assignment: Read pages 56-59. Have someone demonstrate the experiments on pages 57-58.

4. Discuss effect clouds have on weather. Observe clouds in sky, if any. Read pages 52-55 in class and have different children prepare to do the experiments on page 53 and 55. Assign written report on clouds. Due at lesson No. 7. Read pages 59-63 for next time.

5. Put chart on page 61 Teacher's Manual up. Compare with that in English Books. Winds. What makes a hurricane. Talk about hurricanes. See if students can tell the speed of the wind by looking at the school flag. Water and weather : Humidity. Evaporation and precipitation and the water cycle. Demonstrations of experiments on page 64 and 66.

6. Different forms of precipitation. Assign: Read pages 67-74. Dew experiment page 67 as demonstration. Also the one on clouds page 68. Discuss differences between hail, sleet, snow. Assignment: Answer questions.

7. Relationship of weather and climate. Arctic climate pages 80-88. Heat, black and white, slanting rays of sun. Tropical climate pages 88-93. Temperate climate pages 94-96. (This can be tied in with Social Studies.)

8. Film: The Unchained Goddess.

9. Effect of mountains and bodies of water on climate, pages 96-104. Review film.

10. Post test.

If not already done, this can be tied in with English Unit 5, pages 114-137.

Project-Research
Lesson Plans

1. Pre test.

2. Problem: You have been put in charge of forecasting the weather for your area. How would you go about doing this, without the aid of an already existing forecaster in the area? Allow time for thought before discussion.

3. Types of instruments used in weather forecasting: Thermometer, barometer, wind vane, anemometer, rain guage. All of these can be made simply (See Hone.) Practice in reading thermometer and barometer (Correlate arithmetic) and discuss their significance to forecasting.

4. Clouds. Are there different types? Is there some significance to types of clouds. Reading - discussion. Let them puzzle out how to prepare a cloud in the classroom (In a bottle-page 68 text.) Allow several children to try independently and report their results. Discuss what makes a cloud. (Water vapor condensing on dust particles in the air, ice if very high up.) Winds. Measurement of wind speed (anemometer) direction (wind vane). Discussion of hurricane. Compare charts in Teacher's Manual page 61 and that in English book.

5. Humidity (Might bring up the Temperature Humidity Index which is given on radio and TV forecasts in summer.) Have students work with wet and dry bulb thermometers to actually determine the humidity. Where does the water come from? Discussion of the water cycle.

6. Precipitation. What makes the different forms? What is the difference between rain, snow, hail, etc. (Good bulletin board made by students to show the different forms.

7. Effect of location on the earth and weather - Arctic, Tropical, and Temperate climates. (Tie in with Social Studies - latitude and longitude.) Location near large bodies of water.

8. Film - Unchained Goddess

9. Effect of mountains, relation to climate. Brief discussion of weather maps, highs and lows. Are professional forecasters always right? What are some reasons for this?

10. Post test.

It would be interesting to have them actually try to forecast the weather for the following day from whatever instruments they have made or are available. That is without listening to the radio or TV forecasts. If you can work this in, please do so.

ANIMALS

Objectives:

1. To understand the classification of animals.
2. To understand how these groups came about.
3. To understand the general characteristics of the major groups of animals.

Vocabulary:

1. invertebrate
2. vertebrate
3. mammal
4. reptile
5. amphibian
6. bird
7. fish
8. insect
9. head
10. thorax
11. abdomen
12. hibernate
13. migrate
14. warm-blooded
15. cold-blooded
16. protect
17. extinct
18. back-bone
19. skeleton
20. lung
21. gill
22. antenna
23. social
24. solitary
25. estivate
26. egg
27. maggot
28. larva
29. pupa
30. chrysalis
31. cocoon
32. nymphs
33. apiary
34. arthropod
35. metamorphosis

Questions:

1. In what ways are all animals alike?
2. Within these needs, how are the animals different?
3. How would you divide all the familiar animals into groups? Be prepared to explain why you dividie them the way you chose.
4. How do bees keep their colonies going?
5. What advantages are there is social living? In solitary living?
6. Why do animals migrate? Hibernate?
7. What is the difference between hibernation and estivation?

Recitation-Demonstration
Lesson Plans

1. Pre test.

2. List classes of animals known. Make a "family tree" as you go, as well as filling out a chart throughout unit. Read 2-7.

Animals
Invertebrates, Vertebrates
Arachnids Insects Fish Reptiles Mammals
Amphibians Birds

	Protection	Food	Habits	etc.
Mammals				
Birds				
etc.				

3. Insects. Most numerous animal. Why? Question and answer period on assignment. Read pages 7-9 in class and discuss. Be sure they understand pupa, chrysalis and cocoon are the same thing for different insects. Read page 11 and contrast. Assign pages 12-22. Catch insects to keep in class.

4. Discuss assignment. - special ways of insects. (Compare to senses of other animals.) such as compound and simple eyes. Read 23-28 in text and 100-105 in Exploring in Science as an assignment. Have students bring in microscopes, if they have them. Look at insect wings, legs, etc. under the microscopes.

5. Fish. Characteristics - cold-blooded, gills, eggs and leave them. Teacher demonstration - Blood circulation in a goldfish (Hone page 71) Students set up exhibit comparing different insect wings. Be sure a butterfly wing is included for the shingle effect. Assignment: vocabulary.

6. Amphibians. Characteristics- spend ½ their life in water, ½ on land. Young use gills, adults use lungs. Lay eggs in water and leave them. Cold-blooded. Also show microscopic animals.

7. Reptiles. Characteristics - land dwellers, but many like water (alligators and turtles.) Lay eggs and leave them. Cold-blooded. Hibernate. Assign: Questions.

8. Birds. Characteristics - build nests, lay eggs, care for young, warm-blooded. Many migrate, but not all. Review vocabulary and some of questions.

9. Mammals. Characteristics - have live young, warm-blooded. Some hibernate. Care for young. Man - only animal to think and improve himself. General review.

10. Post test.

Project-Research
Lesson Plans

1. Pre test

2. Problem - How did the different animals develop? Discuss meaning of evolution. Look up in dictionary. (NOTE: No discussion of religion or religious significance to be made.) Steer thought to comparisons of learning - simple to complex. The simplest animals came first, becoming more complex.

3. Invertebrates - existed 600 million years ago - soft bodies, sea animals, little is known about them. The crustaceans - still have soft bodies, forerunners of lobsters and crabs. Still sea animals. Lived on minute plant life. Invertebrates of today - insects - little change from 280 million years ago. List characteristics of insects. Discuss arachnids and arthropods.

4. 425 million years ago, the first animals with bones came into being. 400 million years ago - first true fish. Primary difference is the bones. Lived on plants and invertebrate sea animals. List the various characteristics known about fish. Spend time doing reading to find others.

5. Shortly after fish, amphibians came on the scene. The first land animals with bones. Differences - fins became short legs to crawl with; lung developed in adult. List characteristics of amphibians and do more research.

6. 280 million years ago, the first reptiles formed. These animals lived on land, breathed air with lungs. Large reptiles (dinosaurs) appeared in swamp area. Some reptiles formed wings. Early insects arrived about the same time as first reptiles.

7. Some reptiles formed wings of front legs, grew feathers. First birds formed 181 million years ago. They lost their teeth 135 million years ago (true birds). List characteristics of birds.

8. Some reptiles began to produce milk - mammary glands, first mammals. Not much different from reptiles. First began to eat insects. 63 million years ago formation of many different mammals came about. List characteristics of mammals.

9. 1.5 million years ago, the first primates (monkeys, apes, etc.). Characteristics of primates that separates them from other mammals. General review. Be sure students can see the changes from group to group as the evolution of animals has come about.

10. Post test.

APPENDIX B

Topic Tests

PLANTS

1. Food is NOT stored in which of the following plant parts?
(a) root (b) flower (c) leaves (d) bark

2. A farmer set out a row of plants. He put a large amount of fertilizer around each plant and spread mulch around. What would you expect to happen to the plants?
(a) They will thrive. (b) They will wither and die.
(c) They will wilt, but recover quickly. (d) They will thrive at first, but then wither and die.

3. Which plants would you group together?

(a) Plants 1 and 3 (b) Plants 2 and 3 (c) Plants 2 and 4
(d) Plants 1 and 4.

4. A yard was planted with grass seed. Only one side was fenced in, and the other side was trampled by people cutting through the yard. How would you expect the grass to grow on the fenced in side?
(a) Green and thick. (b) Green, but scattered out.
(c) Very poorly. (d) Not at all.

5. What do they call a person who studies and works with plants?
(a) A meteorologist. (b) An entomologist.
(c) A horticulturist. (d) A geologist.

6. You have been given the job of making a garden in a yard which is surrounded by trees. The yard is always cool and moist. Which of the following would be best to use?
(a) Roses and lilies (b) Cacti (c) Fern and violets
(d) Cattails and cypress.

7. A group of people are busy working with fungi. Which of the following tells most exactly what they are doing?
(a) Studying spore producing plants.
(b) Preparing mushroom beds.
(c) Learning about nongreen plants.
(d) Relating plants and animals.

8. What is the primary function of a plant root?
(a) To carry carbon dioxide to the leaves.
(b) To make food for the plant.
(c) To take minerals from the soil for the plant.
(d) To take carbon dioxide from the leaves.

9. Assume that the wind does not blow in a small section of a field. Which of the following plants would be most likely to spread farthest away from the parent plant?
(a) Cherry tree. (b) Strawberry. (c) Dandelion.
(d) Queen Anne's Lace.

10. Which of the following is NOT a part of a flower blossom?
(a) Sepal (b) Pollen (c) Stem (d) Pistil

PLANTS

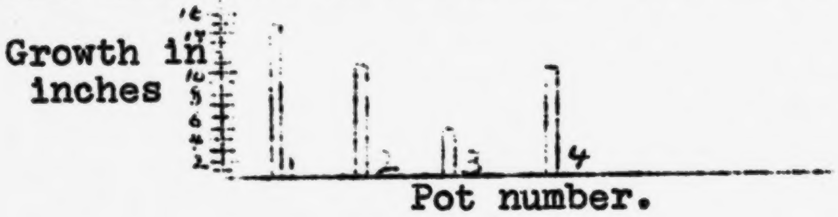
We use different parts of plants as food. Which of the parts below do we use for food in the plants listed in questions 11 and 12?

(a) Roots (b) Leaves (c) Seeds (d) Stems

11. The lettuce plant.

12. Corn.

13. Joe set up an experiment using four pots of bean seeds. He let each pot have a different amount of light. Using the graph tell which pot received the most light.



(a) Pot No. 1 (b) Pot No. 2 (c) Pot No. 3 (d) Pot No. 4.

14. Each of the following plants reproduce in a different way. Assuming each reproduces to its capacity, which one would you expect to have more of the next season?

(a) Iris (b) Geranium (c) Strawberry (d) Radish

15. Pollen is necessary to most flowering plants for which of the following?

(a) To make seeds. (b) To attract birds and bees.
(c) To make the plant beautiful. (d) To form the flower.

16. How long does a perennial plant live?

(a) One year (b) Three years (c) An unknown number of years (d) None of the above.

17. A young boy went through a garden and cut the stamens out of each flower as it bloomed. What would you expect to happen in this garden the following year? Assume that nobody planted any additional flowers.

(a) There would be no flowers. (b) There would be fewer flowers. (c) There would be many more flowers.
(d) There would be the same number of flowers.

You read, in a book by John Jones, a statement which contradicts what you believe to be correct. Which of the following statements are important in determining the value of his statement? Mark -

(a) if the statement might lead you to trust his statement.
(b) if the statement might lead you to distrust his statement.
(c) if the statement is of no value to you.

18. John Jones is Professor of Botany at Oxford University.

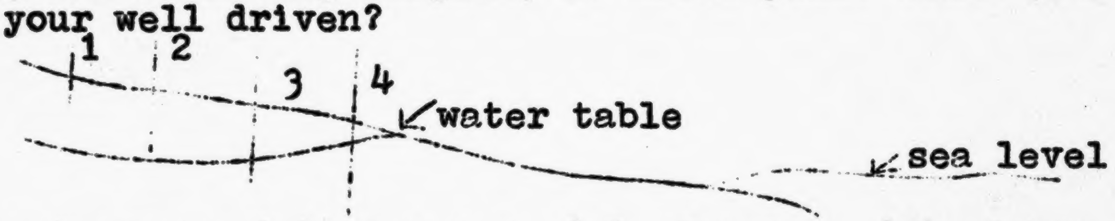
19. John Jones is not listed in American Men of Science.

veral authors of books you have read went to England to

THE EARTH

1. How much of the earth's surface is covered by water?
   (a) $\frac{1}{4}$ (b) $\frac{1}{2}$ (c) 3/4 (d) None of the above.

2. Using the following diagram, at which point would you prefer to have your well driven?



   (a) Point 1 (b) Point 2 (c) Point 3 (d) Point 4

3. What are glaciers made of?
   (a) Packed rocks and dirt. (b) Loose rocks and dirt.
   (c) Packed snow and ice. (d) Loose snow and dirt.

4. Scientists agree with which of the following?
   (a) The earth formed when a star crashed into the sun.
   (b) The earth formed when a star pulled streamers from the sun as it passed.
   (c) The earth was formed by an all powerful being.
   (d) None of the above.

5. A certain field was plowed, harrowed, and ready to be sown. The farmer was called away from the farm, and his helpers did not plant anything. The following year the farmer returned and found rocks strewn all over. What is the best explanation for this?
   (a) The helpers threw rocks from other fields into this one.
   (b) The soil packed down, but not the rocks.
   (c) The soil was carried away, but not the rocks.
   (d) The farmer did not remember correctly.

6. How do glaciers move?
   (a) Very slowly (c) Vary in speed, but usually rapidly.
   (b) Very rapidly (d) Vary in speed, but usually slowly.

7. Which one of the following would you be unable to prove?
   (a) Running water has power. (b) Wind has power.
   (c) Age of the earth. (d) Sugar crystals are cubes.

8. Which of the following is not usually fresh water?
   (a) Rivers (b) Seas (c) Swamps (d) Lakes

9. What does the gravitational pull of the moon cause?
   (a) Earthquakes (b) Tides (c) Thunderstorms (d) Landslides

10. Which of the following can be used to prevent soil waste?
    (a) Plowing the soil in autumn.
    (b) Cutting all trees and pulling out stumps.
    (c) Raking leaves and burning them.
    (d) Planting a cover crop for winter.

11. For what is the stratosphere important?
    (a) Man's living. (b) Aviation (c) Satellites
    (d) All of the above.

12. You have heard the saying "hard as a rock." Here are statements about three different rocks - shale, rose quartz, and limestone. Which statement is most accurate?
    (a) Limestone is harder than the others.
    (b) Rose quartz is harder than the others.
    (c) Shale is harder than the others.
    (d) All three are the same hardness.

13. Which of the following give some indication of the earth's age?
    (a) Rocks (b) Fossils (c) Remains of prehistoric animals
    (d) All of the above.

Assume that something has happened in the middle of the earth causing the force of gravity to become much less than it is right now. With this in mind, mark -

(a) if the statement is true and directly related to the change in gravity.
(b) if the statement is false and directly related to the change in gravity.
(c) if the statement is true but has no relation to the change in gravity.
(d) if the statement is false but has no relation to the change in gravity.

Use the four choices above for questions 14 through 20.

14. The earth would have a new orbit.

15. The tides would become higher.

16. You would weigh considerably more than now.

17. We would find it more difficult to breathe.

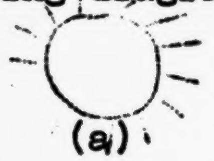
18. The moon would move closer to the earth.

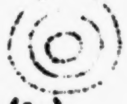
19. We would not notice any difference.

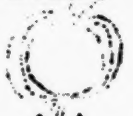
20. Day and night would remain the same.

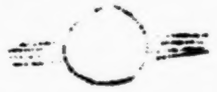
MATTER AND ENERGY

1. The earth is said to have a magnetic field. Which of the following diagrams best shows this field?


(a)


(b)


(c)


(d)

2. Magnets will pick up things made of which of the following?
   (a) Iron, steel, and wood. (b) Iron, nickel, and tin.
   (c) Steel, nickel, and tin (d) Iron, nickel, and steel.

3. Why are lamp cords dangerous when they are worn?
   (a) Electricity can leave the wire where insulation is gone.
   (b) You might cut your leg.
   (c) Static electricity can be dangerous.
   (d) The bulb may blow up.

4. How does light travel?
   (a) In circles (b) In curves (c) In straight lines
   (d) At angles

5. You are trapped in an old mine. You can hear someone walking in the mine shack, but you are not heard. You have found a fuse box as you search the mine. What can you do to get out or get help?
   (a) Break a fuse. (b) Break the whole fuse box.
   (c) Remove the fuse. (d) Turn one fuse in and out of its socket.

6. Sound is caused by which of the following?
   (a) A slowly moving object. (b) A vibrating object.
   (c) An object that is standing still. (d) None of the above.

7. Sunlight can be broken down into the colors of the rainbow by using a prism. What makes us see things as a certain color?
   (a) It absorbs all the light rays.
   (b) It reflects all the light rays.
   (c) It absorbs only part of the light rays, reflecting certain colors.
   (d) None of the above.

8. Why does a mercury switch work?
   (a) Mercury is a magnet. (b) Mercury is a good fuel.
   (c) Mercury is a good conductor. (d) Mercury is a good insulator.

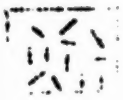
9. How fast does light travel?
   (a) 186 miles per second (b) 1,860 miles per second
   (c) 18,600 miles per second (d) 186,000 miles per second.

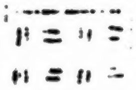
10. You are lost in the woods. You know there is a highway to the east, but you don't know where east is. In your pocket you find a knife, a pencil, paper, string, a bar magnet, and a candy bar. How would you find your way out?
   (a) Toss the knife to determine the direction to go.
   (b) Retrace the way you came on paper.
   (c) Tie the string to the magnet and let it hang free.
   (d) Eat the candy bar and wait to be found.

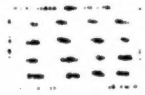
11. How can an electromagnet be made stronger?
    (a) Add more batteries in parallel.
    (b) Make more turns of wire around the nail.
    (b) Use a longer nail.
    (c) Use a longer wire.

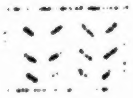
12. Which of the following is the best conductor of electricity?
    (a) Porcelain (b) Copper (c) Aluminum (d) Wood

13. Which of the following diagrams is a magnet?


(a)


(b)


(c)


(d)

14. What is the best definition of transform?
    (a) To make (b) To repair (c) To change (d) To destroy

You are miles away from any houses, on a picnic with a group of friends. Suddenly a thunderstorm comes up. Some of the group started home on their bicycles. Others sat under the tree to keep dry. Some stayed in the water where they had been swimming, and another group just lay on the ground to wait out the storm. Use this information for questions 15 and 16.

15. As the storm approached, what happened first?
    (a) You heard the thunder. (b) You saw the lightning.
    (c) You felt the rain. (d) All three happened together.

16. Which one of the groups was safest?
    (a) Those on their bicycles. (b) Those in swimming.
    (c) Those lying down on the ground. (d) Those under the tree.

17. What is the ability to do work called?
    (a) Matter (b) Energy (c) Change (d) Exchange

18. You are on an island with a primitive tribe. You are tired of their drums constantly beating. With a supply of pipes left over from a construction job, what could you do to relieve the monotony of the drum sound?
    (a) Use the pipe as giant building sticks.
    (b) Hit pipes of different lengths.
    (c) Alternate hitting pipes and drums.
    (d) Use pipes to beat the drums.

19. What is a switch used for.
    (a) To complete a circuit. (b) To break a circuit.
    (c) To control the flow of electricity. (d) All of the above.

20. As you watch a large tank truck move down the street, you notice a chain dragging on the ground behind it. What is the purpose of the chain?
    (a) To prevent electric sparks.
    (b) To enable people to hear the truck.
    (c) The lock chain had broken.
    (d) There was no purpose.

UNIVERSE

1. What is the sun?
(a) Planet (b) Star (c) Comet (d) Satellite.

2. You have made a trip to the moon and have landed safely. As you look at the earth during your stay on the moon, how often would you see the earth rise and set?
(a) Everyday. (b) Once a month. (c) Once a year.
(d) Not at all.

3. Assume that the sun burned itself out, but life continued as usual on earth. Which of the following statements would be true?
(a) The heavens, except for the sun, would remain the same.
(b) We would no longer see the other stars.
(c) We would no longer see the other planets.
(d) We would no longer see any meteors.

4. Which man was the first to use a telescope to look at the heavens?
(a) Galileo. (b) Franklin. (c) Newton. (d) Aristotle.

5. Which of the following planets is closest to the sun?
(a) Pluto. (b) Mars. (c) Mercury. (d) Jupiter.

6. Why does the moon appear to change shape?
(a) Moon and earth rotate together.
(b) Lighted side of moon always faces earth.
(c) Earth does not see all of lighted side of the moon all the time.
(d) None of the above.

7. When is the earth closest to the sun?
(a) Spring. (b) Summer. (c) Autumn. (d) Winter.

8. Mars is somewhat less than one half the size of earth. It is possible that some atmosphere is around it. Assuming that you weigh 100 pounds on earth, what would you expect to weigh on Mars?
(a) 100 pounds. (b) 150 pounds. (c) 50 pounds.
(d) 25 pounds.

9. How long would a day on the moon be?
(a) Approximately one earth day. (b) Approximately ten earth days. (c) Approximately twenty earth days.
(d) Approximately thirty earth days.

10. Which of the following is the best definition of astronomer?
(a) One who studies the heavenly bodies.
(b) One who explores outer space.
(c) One who studies the effect of the stars on people.
(d) An instrument for studying the heavenly bodies.

11. Why do we have high and low tides?
(a) The moon changes its attraction.
(b) The sun changes its attraction.
(c) The earth rotates moving the location of the sun"s attraction.
(d) The earth rotates moving the location of the moon's ttraction.

12. Where we live, when do we see the sun directly overhead?
    (a) At noon in the summer. (b) At noon in the winter.
    (c) At noon in the spring and autumn. (d) None of the above.

13. As the sun, moon, and earth orbit in the solar system, it must happen that the three are in a straight line at various times. Which is most likely to happen when the earth is between the sun and the moon?
    (a) Earth has a full moon. (b) Earth has a new moon.
    (c) An eclipse of the moon. (d) An eclipse of the sun.

14. How many known planets are circling the sun?
    (a) Three (b) Six (c) Nine (d) Twelve

The earth has speeded up in its orbit around the sun. Instead of 365¼ days for a complete revolution, it now takes only 200 days. For questions 15 through 19 use the following.

(a) If statement is true and directly related to the change in orbit time.
(b) If statement is false and directly related to the change in orbit time.
(c) If statement is true, and there is no relation to the change in orbit time.
(d) If statement is false, and there is no relation to the change in orbit time.

15. The year is shorter.

16. There are four seasons.

17. The seasons are longer.

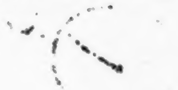
18. Day would be 18 hours.

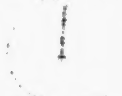
19. Farmers lives would change considerably.

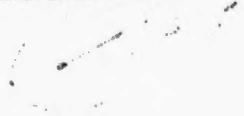
20. What causes night and day?
    (a) The sun moving around the earth.
    (b) The earth moving around the sun.
    (c) The sun spinning on its axis.
    (d) The earth spinning on its axis.

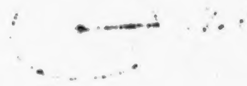
WEATHER

1. The radio says a storm is coming, and it has already started to rain. Bob checks his barometer and those of several friends. Which barometer was probably most accurate?


Fred


Bob


Jim


Dan

(a) Fred s. (b) Bob's. (c) Jim's. (d) Dan's

2. What is snow?
(a) Water droplets, frozen to ice. (b) Ice crystals.
(c) A mixture of ice and water. (d) Ice frozen in layers.

3. You have been asked to make a forecast based on this information: Temperature 32°F; Barometer 29.8 and falling; Thick stratus cloud cover. What is your forecast?
(a) Cloudy and cold. (b) Rain. (c) Cloudy with clearing later in the day. (d) Rain mixed with sleet, or snow.

4. Why does the wind usually blow from the sea toward the land in the daytime?
(a) There is more water vapor in the air over the sea.
(b) The sea is warmer than the land.
(c) The land is warmer than the sea.
(d) The waves push the wind.

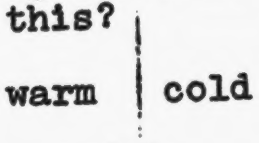
5. Which instrument is used to measure the speed of wind.
(a) Kilometer. (b) Anemometer. (c) Barometer.
(d) Hygrometer.

6. On a hot (94°F), humid (96%) day, most people seem to be very uncomfortable. Which of the following is the best reason for this?
(a) People always feel uncomfortable on hot days.
(b) It is going to rain.
(c) Evaporation takes place very slowly.
(d) Pressure is usually high.

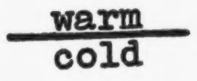
7. What does a changing barometer indicate?
(a) A storm. (b) Clear weather. (c) Weather staying the same. (d) A change in the weather.

8. What instrument is used to measure air pressure?
(a) Barometer. (b) Hygrometer. (c) Thermometer
(d) Kilometer.

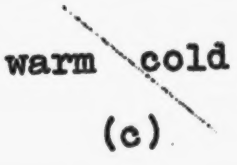
9. A block of warm air has moved up to a block of cold air, forming a front. Which of the following pictures would best show this?



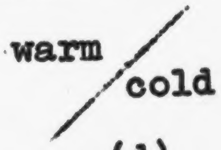
(a)



(b)



(c)



(d)

10. What type of weather would you predict along the front in question number 9?
(a) Rain. (b) Cloudy. (c) Fair and warm.
(d) Fair and cold.

11. Mrs. Jones went to the mountains for a vacation. While making breakfast, she found the eggs, boiled the same time as at home, were not done well enough. Why was this so?
    (a) Eggs are fresher in the mountains.
    (b) Water boils quicker in the mountains.
    (c) Water is colder in the mountains.
    (d) Air is heavier in the mountains.

12. What causes winds?
    (a) A difference in humidity. (b) A difference in temperature
    (c) A difference in pressure. (d) None of the above.

13. As you climb to the top of a very tall building, you are observing the readings of a barometer. Which of the following would you expect to happen?
    (a) There would be a sudden change.
    (b) There would be no change.
    (c) It would increase gradually.
    (d) It would decrease gradually.

14. What satellite is used for weather observations?
    (a) Echo. (b) Gemini. (c) Tyros. (d) Ranger.

15. What is the relationship between frost and dew?
    (a) One forms at high pressure, the other at low pressure.
    (b) One forms at high temperature, the other at low temperature.
    (c) One forms in the morning, the other in the evening.
    (d) There is no relationship.

16. Which of the following would form clouds high in the atmosphere?
    (a) Water. (b) Dust. (c) Gases. (d) Ice.

17. In which part of the atmosphere do clouds appear?
    (a) Troposphere. (b) Stratosphere. (c) Ionosphere.
    (d) The entire atmosphere.

18. What are people who study weather called?
    (a) Geologists. (b) Biologists. (c) Astronomists
    (d) Meteorologists.

Cumulonimbus clouds are gathering in the northeast. The wind is blowing them towards you.

19. What type of weather do these clouds indicate?
    (a) Fair weather. (b) Light showers. (c) Thunderstorms.
    (d) Long rainy days.

20. As these clouds get closer, what will happen to the air pressure?
    (a) It will increase. (b) It will decrease.
    (c) It will remain steady. (d) It will vary, up and down.

ANIMALS

1. Bill's father invited Miss Thompson's class to visit his apiary. What was the class going to do?
   (a) Raise ants. (b) Study bees. (c) Work with reptiles. (d) Compare several animals.

2. A cat and a dog are alike in many ways. Which of the following is not true?
   (a) Both are warm-blooded. (b) Both are domestic animals.
   (c) Both are reptiles. (d) Both have four legs.

3. In studying the effect of a certain treatment on future generations, which of the following would be most important in a controlled experiment?
   (a) Work only with humans.
   (b) Choose an animal that has many young at one time.
   (c) Give all animals the same treatment.
   (d) Choose an animal with a short life cycle.

4. What is the correct order in the life stages of a housefly?
   (a) larva - egg - pupa - adult.
   (b) pupa - larva - adult - egg.
   (c) egg - larva - pupa - adult.
   (d) pupa - egg - larva - adult.

5. What is the relationship between hibernate and estivate?
   (a) Both are the same.
   (b) Both are the same but apply to different classes of animals.
   (c) Both are the same, but apply to different times of the year.
   (d) There is no relationship.

6. What must you do in order to compare animals?
   (a) Observe them carefully. (b) Feed them well.
   (c) Be a hunter. (d) Love animals.

7. Which of the following animals undergoes a complete metamorphosis?
   (a) Frog. (b) Dog. (c) Alligator. (d) Grasshopper.

8. Which of the following animals does not belong with the others?
   (a) Bear. (b) Ant. (c) Dog. (d) Turtle.

9. What is the best definition of hibernate?
   (a) Go to cold climate for the summer.
   (b) Go to warm climate for the winter.
   (c) Sleep all summer.
   (d) Sleep all winter.

10. Which of the following insects does not belong with the others?
    (a) Ant. (b) Butterfly. (c) Housefly. (d) Grasshopper.

11. What do we call all animals who have hair or fur and who nurse their young?
    (a) Reptiles. (b) Birds. (c) Mammals. (d) Amphibians.

12. Many animals come out at night and sleep during the day because they feel somewhat safer, but animals in a particular environment do this just to stay alive. Which environment is this?

(a) Desert. (b) Arctic. (c) Mountain. (d) Forest.

13. What are scientists who study living things known as?

(a) Chemists. (b) Biologists. (c) Engineers. (d) Geologists

14. Many animals are useful to man. Which of the following keeps rodents out of the garden?

(a) Horse. (b) Sheep. (c) Cat. (d) Geese.

15. What is the difference between reptiles and amphibians?

(a) Reptiles breath with lungs; amphibians use lungs and gills.

(b) Reptiles lay eggs; amphibians do not.

(c) Amphibians lay eggs; reptiles do not.

(d) Amphibians breath with lungs; reptiles use lungs and gills.

For questions 16 - 20 use the following.
Mark

(a) If an increase in the first item usually means and increase in the second.

(b) If an increase in the first item usually means a decrease in the second.

(c) If an increase in the first item has no effect on the second.

16. The number of owls in a section of woods.
The number of rabbits in the same section of woods.

17. The amount of plant life in a field.
The amount of animal life in the same field.

18. The number of snails in an aquarium.
The amount of algae in the same aquarium.

19. The temperature of the environment of a mammal.
The temperature of the mammal.

20. The number of fish in a pond.
The number of mosquitoe larvae in the same pond.

BIBLIOGRAPHY

Abramson, Bernard, "A Comparison of Two Methods of Teaching in High School," *Science Education 36* (March, 1952), 96-106.

Alterman, George, "A Comparison of the Effectiveness of Two Teaching Techniques on the Ability of College Students to Apply Principles of Physics to New Technical Problems," Unpublished Ph.D. dissertation, New York University, 1957.

Anibel, Fred G., "Comparative Effectiveness of the Lecture Demonstration and Individual Laboratory Method," *Journal of Educational Research 13* (May, 1926), 355-365.

Atkin, J. Myron, "A Study of Formulating and Suggesting Tests for Hypotheses in Elementary School Science Learning Experiences," *Science Education 42* (December, 1958), 414-422.

Barnard, J. Darrell, "Developments in Science Education," *Educational Leadership 19* (January, 1942), 215-219.

________, "The Lecture-Demonstration Versus the Problem-Solving Method of Teaching a College Science Course," *Science Education 26* (October, 1942), 121-132.

Barnes, Cyrus, "Problems of Research and Implications in Teaching Science in the Elementary School," *School Science and Mathematics 61* (November, 1961), 595-600.

Benz, Grace, "An Experimental Evaluation of Field Trips for Achieving Informational Gains in a Unit on Earth Science in Four Ninth Grade Classes," *Science Education 46* (February, 1962), 43-47.

Blackwood, Paul E., "Science Education," *Educational Leadership 19* (January, 1962), 267-276.

Bloom, Benjamin S., ed. *Taxonomy of Educational Objectives, Handbook I: Cognitive Domain.* New York: David McKay Company, Inc., 1956.

Boeck, Clarence H., "The Inductive-Deductive Compared to the Deductive-Descriptive Approach to Laboratory Instruction in High School Chemistry," *Journal of Experimental Education 19,* (March, 1951) 247-253.

________, "The Relative Efficiency of Reading and Demonstration Methods of Instruction in Developing Scientific Understandings," *Science Education 40* (March, 1956), 92-97.

Boyer, Donald Allen, "A Comparative Study of the Science Achievement of Pupils in Elementary Schools," *Science Education 39* (February, 1955), 3-12.

Branley, Franklyn M., "Experiments and Demonstrations," *Grade Teacher 78* (October, 1960), 53, 125+.

Carpenter, Finley, "The Effect of Different Learning Methods on Concept Formation," *Science Education 40* (October, 1956), 282-285.

Carpenter, Regan, "A Reading Method and an Activity Method in Elementary Science Instruction," *Science Education 47* (April, 1963), 256-258.

Carpenter, W. W., "A Study of the Comparison of Different Methods of Laboratory Practice .on the Basis of Results Obtained on Tests of Certain Classes in High School Chemistry," *Journal of Chemical Education 3* (July, 1926), 798-805.

Collings, Ellsworth. *An Experiment with a Project Curriculum.* New York: The Macmillan Company, 1929.

Colyer, Luther Melvin and Anderson, Kenneth E., "A Comparison of Two Methods of Teaching Formula Writing in High School Chemistry," *School Science and Mathematics 52* January, 1952), 50-59.

Commoner, Barry, "Is Science Getting Out of Hand?" *The Science Teacher 30* (October, 1963), 11-16.

Craig, Gerald S., "Elementary School Science in the Past Century," *The Science Teacher 24* (February, 1957), 11-14+.

Cronbach, Lee J. *Educational Psychology.* New York: Harcourt Brace & World, Inc., 1963.

Croxton, W. C. *Science in the Elementary School.* New York: McGraw Hill Book Company, Inc., 1937.

Cunningham, Harry A., "Lecture Demonstration Versus Individual Laboratory Method in Science Teaching - A Summary," *Science Education 30* (January, 1946), 70-82.

Dawson, Murray D., "Lectures Versus Problem Solving in Teaching Elementary Soil Science," Science Education 40 (December, 1956), 395-404.

Decker, Donald G., "Trends in Sequence and Organization," Instructor 73 (January, 1964), 43+.

DiLorenzo, Louis T., and Halliwell, Joseph W., "A Comparison of the Science Achievement of Sixth Grade Pupils Instructed by Regular Classroom and Special Science Teachers," Science Education 47 (January, 1963), 202-205.

Elder, Albert L., "The Lecture-Demonstration Method vs Individual Laboratory Work in Chemistry," Science Education 23 (April, 1939), 209-215.

Falk, Doris F., "The Learning of Chemical Equations: Meaningful Versus Mechanical Methods," Science Education 46 (February, 1962), 37-42.

Garside, Leonard James, "A Comparison of the Effectiveness of Two Methods of Instruction in High School Physics as Measured by Levels of Achievement of Students of High and Low Intelligence," Unpublished Ph.D. dissertation, University of Wisconsin, 1959.

Gibb, E. Glenadine and Matala, Dorothy C., "Study on the Use of Special Teachers of Science and Mathematics in Grades 5 and 6," School Science and Mathematics 62 (November, 1962), 565-585.

Ginther, J. R., "Achievement in Sixth Grade Science Associated with Two Instructional Roles of Science Consultants," Journal of Educational Research 57 (September, 1963), 28-33.

Greene, Robert Alonzo, "A Comparative Study of the Efficiency of Dramatic and Non-Dramatic Methods in Teaching Science to Fifth Grade Children," Unpublished Doctor's Thesis, Cornell University, 1937.

Hetland, Melvin, "Developing Science Concepts Inductively," The Science Teacher 24 (May, 1957), 172-173+.

Hosley, Charles T., "Learning Outcomes of Sixth Grade Pupils Under Alternate Grade Organization Patterns," Unpublished Ed.D. dissertation, Stanford University, 1954.

Hubbard, George Wendell, "The Effect of Three Teaching Methods on Achievement in a Senior High School Physics Course," Unpublished Ed.D. dissertation, The University of Oklahoma, 1958.

Huffmire, Donald Wynant, "Criteria for Independent Study Projects," The Science Teacher 28 (May, 1961), 32-33+.

Hurd, Paul DeHart, "The New Curriculum Movement in Science," The Science Teacher 29 (February, 1962), 6-9.

Jersild, Arthur T., at. al., "An Evaluation of Aspects of the Activity Program in the New York City Public Elementary Schools," Journal of Experimental Education 8 (December, 1939), 166-207.

Johnson, Palmer O., "A Comparison of the Lecture Demonstration, Group Laboratory Experimentation, and Individual Laboratory Experimentation Methods of Teaching High School Biology," Journal of Educational Research 18 (September, 1928), 103-111.

Johnson, Philip G., "Science Education Research Studies - 1952," Science Education 38 (February, 1954) 8-38.

Kahn, Paul, "An Experimental Study to Determine the Effect of a Selected Procedure for Teaching the Scientific Attitudes to Seventh and Eighth Grade Boys Through the Use of Current Events in Science," Science Education 46 (March, 1962), 115-127.

Karplus, Robert, "Meet Mr. O.," Science and Children 1 (November, 1963), 19-24.

Kerlinger, Fred N. Foundations of Behavioral Research. New York: Holt, Rinehart and Winston, Inc., 1965.

Kilburn, Robert E., "Hypothesis Testing: A Student Activity Approach," The Science Teacher 30 (November, 1963) 51, 53.

Knox, W. W., "The Demonstration Method Versus the Laboratory Method of Teaching High-School Chemistry," Science Review 35 (May, 1927), 376-386.

Kruglak, Haym, "A Comparison of the Conventional and Demonstration Methods in the Elementary College Physics Laboratory," Journal of Experimental Education 20 (March, 1952), 293-300.

Lahti, Arnold M., "Scientific Methodology - The Education for a Changing World," Science Education 47 (March, 1963), 157-163.

Macomber, F. G., "Living in a World of Science," in Principles of Teaching in the Elementary School. New York: American Book Company, 1954. pp 214-229.

Mallinson, Jacqueline V., "The Current Status of Science Education in the Elementary Schools," School Science and Mathematics 61 (April, 1961), 252-270.

Manning, John A., "Science Project Ideas," The Science Teacher 24 (March, 1957), 67-68.

Mason, John M., "An Experimental Study in the Teaching of Scientific Thinking in Biological Science at the College Level," Science Education 36 (December, 1952), 270-284.

Matala, Dorothy C., "Current Activities in Elementary and Junior High School Science," School Science and Mathematics 61 (May, 1961), 339-367.

Milgrom, Harry, "What Materials for Science Teaching," Science and Children 1 (September, 1963), 20.

Mork, Gorden Matther A., "Effects of an In-Service Teacher Training Program on Pupils Outcomes in Fifth and Sixth Grade Science," Unpublished Ph.D. dissertation, University of Minnesota, 1953.

Nash, H. B., and Phillips, M. J. W., "A Study of the Relative Value of Three Methods of Teaching High School Chemistry," Journal of Educational Research 15 (May, 1927), 371-379.

Newman, Earl Nelson, "A Comparison of the Effectiveness of Three Teaching Methods in High School Biology," Unpublished Ed.D. dissertation, The University of Oklahoma, 1957.

Norton, Jerry L., "The Need for an Activity Centered Science Program," Science Education 47 (April, 1963), 285-291.

Rainey, Robert G., "A Comparison of the CHEM Study Curriculum and a Conventional Approach in Teaching High School Chemistry," School Science and Mathematics 64 (October, 1964), 539-544.

Robertson, Martin L., "An Investigation to Determine the Relative Effectiveness of Two Methods of Teaching Elementary Science in the Fifth Grade," Science Education 16 (February, 1932), 182-187.

Scott, Lloyd, "An Experiment in Teaching Basic Science in the Elementary School," Science Education 46 (March, 1962), 105-108.

Sequential Tests of Educational Progress, Teacher's Guide. Princeton, New Jersey: Educational Testing Service, 1959.

Smith, Gary R., and Victor, Edward, "Use of Standardized Science Achievement Tests for Grade Placement," The Science Teacher 28 (February, 1961), 11-14.

Stefaniak, Edward W., "A Study of the Effectiveness of Two Methods of Teaching Science in Grades Four, Five, and Six," Unpublished Ed.D. dissertation, Boston University School of Education, 1955.

Suchman, J. Richard, "Inquiry Training in the Elementary School," The Science Teacher 27 (November, 1960), 42-47.

Swezey, Kenneth M., "Classic Experiments in Modern Dress," Science and Children 3 (October, 1965), 6-9+.

Turner, George C., "Problem Solving: A Changing Concept," The Science Teacher 24 (November, 1957), 339+.

Underhill, Orra Ervin, The Origins and Development of Elementary School Science. New York: Scott Foresman and Company, 1941.

VanDeventer, W. C., "A Common Denominator for Scientific Problem Solving," The Science Teacher 27 (February, 1960), 41-42.

Victor, Edward, "Why Are Elementary School Teachers Reluctant to Teach Science?" The Science Teacher 28 (November, 1961), 17-19.

Weaver, Elbert C., "Demonstration IS Teaching," The Science Teacher 31 (February, 1964), 34-35.